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OF THE

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ALL-INDIA
SANITARY CONFERENCE

HELD AT

LUCKNOW

January 19th to 27th, 1914

VOLUME II

PAPERS

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REPORT* ON THE CONTROL AND UTILIZATION OF RIVERS AND DRAINAGE FOR THE FERTILIZATION OF LAND AND MITIGATION OF MALARIA.

BY

SIR EDWARD BUCK, K.C.S.I., LL.D.

PREFATORY ABSTRACT.

1. The utilization of silt for the fertilization of land has been carried out on an important scale in Italy since the XIIth Century, many hundreds of square miles of unwholesome depressions of poor soil having been rendered healthy and fertile by silt deposit previously to the unification of Italy.

2. Since the unification in 1862 the Government has undertaken a still wider campaign against malaria throughout Italy by the agency of silt deposit combined with drainage. There are now 249 projects in hand, covering an area of 4,300 square miles, of which nearly half are approaching completion.

3. The annual expenditure on these projects has increased from about 15 to about 50 lakhs of rupees a year; 9 million sterling have been expended in 42 years. Earlier operations have, some of them, been unremunerative owing to inexperience and political interruptions. But more recent works have, many of them, been highly profitable, returning 20 per cent. on capital outlay.

4. The results have been achieved by securing the control of the rivers and of the drainage system in the plains throughout the country.

5. In addition to the operations conducted by Government a large number of works are carried out by associations of private owners with or without official assistance. But whereas the primary object of the Government is expulsion of malaria, followed by fertilization of land, the primary object of the private owner is agricultural improvement, followed by improved sanitation.

6. During the last century a system has been developed of securing the control also of rainfall and drainage in the hills, by which erosion is prevented and ravines and depressions are converted into fertile belts of good soil.

7. Can Italian methods be usefully applied to India? As regards low-lying lands in the plains there are two distinct issues: (1) the expulsion or diminution of malaria, (2) the fertilization of soil. The first object can be partially effected by drainage, and it is noted that a large drainage scheme for this purpose is under contemplation in Bengal. But to use the Italian expression, *the lowering of the level of water should be combined with the raising of the level of the soil.* How the two systems are combined in Italy requires a study of Italian methods (which are the result of centuries of experience and development) by competent engineers.

8. At a recent Agricultural Conference in Italy it was "resolved" that although drainage might be desirable for the *rapid* conversion of unwholesome into wholesome tracts it would be a "grave error" not to follow drainage, wherever possible, with silt deposit.

9. The virtues of silt deposit are not unknown in India. In 1893 I was permitted to issue a circular enquiring how far the practice of using silt deposit prevailed. The answers imply that in some parts of the country the cultivators use it with or without official help, but that in most Indian districts little or nothing is done in this direction, and that nowhere was there any comprehensive scheme for the control of rivers and drainage with the object of preventing malaria or of fertilizing land.

10. Similar evidence was given regarding the control of drainage in hills and ravines for the prevention of erosion and for the fertilization of land. Sporadic work of the kind had been done in various places with or without official help, but no comprehensive scheme had been undertaken in any province. A commencement on an important scale seems, however, to have been made in the Bombay

* Report submitted to Government, 1907.

Presidency, where, this year, several lakhs have been granted for the control of drainage in hills and ravines as a famine work.

11. Such works were recommended for famine relief in the first Famine Code, but have not been hitherto seriously utilized. It would seem desirable that they should be included in the programmes of famine relief works.

12. The successful system referred to in paragraph 6 developed in Italy for the control of drainage in hills and ravines is novel and unknown in India. This also seems to require study in Italy by competent engineers.

13. Another matter which is considered of importance by the agricultural authorities in Italy is the formation and training of corps of agricultural engineers as has been done in Germany and more recently in France. This question seems to deserve consideration in India.

14. Next to water, the great want of India, especially of Upper India, is manure. Oilcake and bones, two of the principal manures of Europe, are exported; stable manure is most of it burned. Chemical manures are too costly. It would seem to be a " grave error " not to utilize river silt, wherever available, as an additional manure supply. Both from Italy and India it is reported that good silt deposit requires no other manure for ten years.

15. The immediate measures suggested are:—

(1) The continued analysis of silt in rivers and canals when in flood after heavy rain.

(2) The deputation of a competent engineer or engineers for the study of methods in Italy.

(3) The construction of drainage maps, on the inexpensive system explained in the report.

(4) The general discussion of the questions involved at the annual agricultural conference in February 1907.

16. Further questions may be brought under consideration in later years, such as :—

(5) Whether the silt of Indian rivers and canals, especially in Sub-Himalayan tracts, can be profitably utilized.

(6) Whether notoriously unhealthy tracts, such as the Terai, can be treated on Italian methods for the checking of malaria.

(7) Whether schemes can be prepared for inclusion in famine relief programmes.

(8) How far existing canals can be utilized for the distribution of fertile silt.

Other questions of importance will arise in the course of discussion.

Section I.—In Italy.

Harnessing of rivers in Italy.

1. History shows that in the utilization of the waters of their rivers for various useful purposes the Italians have long given lessons to the world. For some centuries past they have taken the utmost pains, quoting their own phrase, " to put the bridle on " one after another of their streams. It was at the end of the twelfth century that, following the lead of their Roman ancestors, they began to turn their rivers into canals, of which the objects were to carry irrigation to the agricultural lands and potable waters to the towns. Two of the most important of such works in operation at the present day were constructed not less than seven hundred years ago. But the supply of irrigation and pure drinking water have not been the only objects for which they have harnessed their streams for, as time went on, they found that they could, to quote one of their writers, " use the waters of a river as a weapon of defence against the destructive and pernicious influences of the very river itself." Leonardo da Vinci, whose genius as an engineer was even more remarkable than his skill as a painter, had been among the first to point the way. The heading of the 53rd chapter of his great treatise on the " Movement and measurement of waters " is " *How with the running waters we ought to carry the earth of the mountains into the valleys, so as to render them fertile and to purify the air.*" And for the last five centuries the intelligence of the Italian engineers has been directed to forcing each stream to turn the swamps which it had itself caused into fertile plains, and to build up with its own silt rich terraces in the very ravines which it had torn from the hillsides.

Various uses of river water and silt.

[Idraulica rulale. 1902. Ricerea-ed usi agrari delle acque, 1904. By Ing. V. Niccoli published by Barbera, Florence.]

2. There is an extensive literature on the subject of the control and utilization of rivers and streams in Italy. But the most recent and comprehensive treatises are two works entitled " Rural hydraulics " and " The Agricultural uses of waters," published in 1902 and 1904, respectively, by Engineer V. Niccoli, formerly Professor of Rural Economy in the School of Agriculture at Milan and now Professor of Agricultural Chemistry at the Pisa University. It may be useful to follow to some extent the division of subjects which this writer has

adopted in his treatises, omitting only those, such as subsoil drainage, domestic and industrial uses of water, etc., which do not relate to the direct use of the waters of the stream for agricultural purposes, or to the improvement of land by drainage canals.

The division which may be thus adopted comprises the following subjects :—

I. Irrigation, or the supply of water to crops.
II. Fertilization of land by irrigation.
III. Fertilization of land by submersion.
IV. Protection against frost by submersion.
V. *Bonificazione* in the plains —(*a*) by drainage.
—(*b*) by silt deposit.
VI. *Bonificazione* in the hills by silt deposit.

The term "Bonificazione" has been retained because it is untranslatable except by a paraphrase. It means the improvement by drainage and by silt deposit not only of the agricultural value of the land treated, but also, as a rule, of the climate of the area dealt with. The term is used in Italy as a general heading in all official publications and papers relating to such improvement.

The various subjects may now be dealt with under each head.

I.—Irrigation or the supply of water to crops.

I. Irrigation or the supply of water to crops.

3. Irrigation from canals or otherwise is dealt with by Professor Niccoli and other Italian writers in great detail into which it is unnecessary to follow them since, except so far as concerns water which contains fertilizing silt, the subject lies outside the scope of the present report. But it may be interesting to note that more than half a century ago three of the pioneers of our Indian canal system (Coutley, Smith-Baird and Scott-Moncrieff) travelled through Southern Europe to study the irrigation works and methods of France, Spain and Italy, learning lessons which have been applied not only to India, but in later years to Egypt with so much success. For one of the three Royal Engineers who made the Italian tour in the forties was, as General Sir Scott-Moncrieff, the distinguished official who has done so much to develop the fertilization of Egyptian lands by the waters and silt of the Nile. And, as will be explained in a later paragraph, it was a chapter in the report by this officer which dealt with the enrichment in the Moselle country of a "barren and worthless valley by no manure save the alluvial matter deposited by abundant irrigation" that drew my own attention to the importance of studying the subject in Italy, from which country France had derived the system.

During the last fifty or sixty years, however, the Italians have worked out many developments in their system of canal construction as well as in their methods of water distribution which it might still be worth while for our Indian engineers to investigate.

II.—Fertilization of land by irrigation with silt-laden water.

II. Fertilization of land by irrigation with silt-laden water.

4. This was a special subject of the present enquiry. The assumption had been made that the main object of the prolonged irrigation of fields in Lombardy was the deposit of fertilizing matter, but as will be noted under heading IV this is not the case. The advantage of irrigating fields and crops with water containing useful silt has not, however, been overlooked in Italy. But it is chiefly applied to grass meadows and vineyards in the older lands, both in the case of rich drainage from towns and of silt-bearing waters from the rivers. The system is, as in some parts of India, freely applied to rice lands, and Professor Niccoli advocates its more extensive application to land prepared for other crops or to the crops themselves when they are sufficiently high. It is also employed, after a term of years, for the refreshment of the extensive areas which, as will be described under heading V (*b*), have themselves been built up with river silt and which require no further manure of any kind for at least a decade. As time goes on and the silt-bearing waters are no longer wanted for the formation of new lands, it is intended to utilize the water for the renovation of fertility to a much greater extent. It will then be a question for the agricultural experts to decide how far the silt-bearing water can, as advised by Professor Niccoli, be applied to crops on the ground. At present the silt-formed land which receives the periodically renewed dressing of silt is thrown out of cultivation for the season.

It may be interesting to quote the following remarks on the subject by Professor Sistini, of the Pisa University, which occur in an official collection of papers on agricultural manures. He is discussing the value of the silt carried by the river Arno.

"The analysis shows," he writes, "that one quintal of sediment left by the river Arno contains, when air dried, about as much azote, potash and phosphoric acid as would be obtained in half the amount of stable manure . . . It is certain

that an *irrigation* made at due time and in a favourable locality can carry on the ground a quantity of fertilizing elements comparable with those which would be supplied by the purchase of matured stable manure independently of the raising of the soil and of the advantages of controlling drainage."

This is practically the argument adopted in my own previous notes on the subject of irrigating land with silt-bearing water.

III.—Fertilization of land by submersion.

III. Fertilization of land by submersion.

5. Under this heading Professor Niccoli comprises the lands flooded and fertilized by large rivers, such as the Nile, and proceeds to discuss how far this system of fertilization is or can be imitated or expanded by artificial means in Italy. Naturally rice-lands are more than any others susceptible to a treatment of the kind. But in his publication of 1904 he shows with the aid of diagrams the system on which it is carried out on gradually descending fields ; a system which could be, *mutatis mutandis*, probably applied to many submontane tracts in India, as well as perhaps in the upper deltas of Indian rivers. Use indeed is made on some Indian rivers of flood overflow, and on the river Indus is likely to receive considerable extension by the construction of a *barége* across its lower waters on the Nile plan. But the details of the methods described by Professor Niccoli would, perhaps, be worth a study by our engineers in connection with the distribution of flood overflow on higher parts of the streams. They cannot be well explained on paper without the assistance of such diagrams as are given in Professor Niccoli's Treatise of 1904 (*pp.* 319, *et seq*).

IV.—Protection against frost by submersion.

IV. Protection against frost by submersion.

6. The main object of the extensive submersions of the plains of Lombardy known as *marcite*, is the protection of the grass and herbage of pasture lands from frost. The practice, being one which is of hardly possible application to India, unless in the extreme north-western districts on the frontier, would not have been discussed in this report but for the circumstance that when the present enquiry into Italian methods was suggested it was assumed that a main object of the submersions was the fertilization of the submerged lands. This is not the case. Some writers, it is true, allege that the soil is favourably affected and chemical investigations are still proceeding for the ascertainment of the real effect on the soil ; but it may be at once said that the water spread on the Lombardy meadows does not carry on to them any material quantity of useful silt, seeing that the water is brought from the mountains at a time when it is comparatively pure.

I have recently received a memorandum from the Secretary of the British Board of Agriculture which indicates that a similar system prevails in some English countries under the name of *water meadows*.

It may be noted in concluding this subject that skilled cultivators in Upper India are aware of the protection which water and the vapour of water afford against frost. Thus in the Doab, on the few days preceding the nights when frost may be expected, the market gardeners hurriedly run water over fields occupied by tobacco, potatoes and other valuable crops in order to prevent their being frost-bitten. And with reason. For, in view of the fact that it has been scientifically established that vapour of water is more impermeable to heat rays than any known substance, it can be readily understood that the *stratum* of moisture temporarily raised over the crop prevents any heat escaping from the soil.

V.—Bonificazione.

V. Bonificazione.

7. The explanation already given of "Bonificazione" as the improvement of the climate as well as of the soil of the areas dealt with applies accurately only to the low-lying lands of the plains, for in the elevated tracts it is the soil alone and not the climate that is affected. History indicates that the primary object of the operations undertaken under this name, which were for some centuries confined to the plains, were hygienic rather than agricultural, and it has, in fact, only been in the last hundred years that the hilly regions have been brought under treatment.

Bonificazione as applied to the plains includes on the one hand the drainage of water-logged tracts and on the other hand the building up (*colmata*) of low-lying lands by the application of river silt. In other words, it includes the lowering of the level of the water and the raising of the level of the land. These are the two measures with which the Italians have successfully expelled malaria from several hundreds—indeed some thousands—of square miles of their country. To anyone to whom a knowledge of the facts is brought for the first time both the magnitude of the work which has been and is being done, and the patience with which it has been and continues to be carried on, must be the cause of surprise and admiration. It is true that the evil which had to be removed was great. But the same remark

applies to countries where little or nothing has been done towards its mitigation. Malaria, it may be admitted, is far less sensational than plague or cholera, to combat which so much costly effort has elsewhere been directed, but it is far more destructive. And to the Italians the credit is due of, long before recent discoveries, recognizing the devastating influence of the disease ; of studying with care the conditions favourable to its prevalence ; and of modifying those conditions in such a way as to make the disease impossible. It is equally to their credit that they were the first to study the history of the malarial germ in the blood and to lead to the discovery of the mosquito as its cause.

It is now not too much to say that malaria has been effectively expelled from the thousands of square miles of Italy, which have been brought under treatment by *Bonificazione*. At the same time there has been reaped a substantial reward. For the very means which have been adopted to make the land habitable have at the same time conferred upon it such exceptional fertility that tracts in which man could formerly hardly live are now crowded by a prosperous peasantry.

Early history of *Bonificazione*.

8. The history of *Bonificazione* is a long one. It began with the drainage of marshes by the Romans. But no comprehensive schemes were undertaken until the twelfth century, when measures were commenced for the drainage and amelioration of the historical "Val di Chiana" as well as of the low-lying tracts which surrounded it in the adjacent region. It is interesting to record here that the first to study the question of silt deposit, to which the reclamation of this valley is due, was Evangelista Torricelli, a pupil of Galileo. The Chiana valley itself comprises an area of eight hundred square miles and the neighbouring depressions, which lie in a circle round Florence, many hundred square miles more. The history of the operations recently drawn up in the Ministry of Agriculture indicates that it was not until the sixteenth century that a sensible improvement was realized ; but from that time the "building up" (*colmata*) of the valleys continued until towards the end of the eighteenth century, when it was authoritatively pronounced that malaria had been finally expelled from the Val di Chiana. "*All the transformations have been due,*" says the official report, "*to the natural deposit of silt spread over the land by lateral streams directed more or less by man.*" More had still to be done. In 1782, adds the report, irregularities of surface had to be smoothed, and imperfections of drainage corrected, and it was then that Fossembrosi, one of those engineers and mathematicians of genius of whom Italy has possessed so many, was called upon to continue the work, which in 1838 he bequeathed to an equally distinguished successor, Manetti, who, though finding the vast plain "absolutely free from fever and the land in perfect agricultural conditions," discovered serious imperfections still existing in the system of drainage. It was not until 1860 that the work was actually concluded.

Bonificazione due to best brains of Italy.

9. It has been thought desirable to mention the names of the engineers and men of science whom, selecting the best brains in its service, Italy employed on one of the largest and most successful operations which come under the appropriate designation of "*Bonificazione.*" For malaria cannot be successfully combated merely by the distribution of quinine and the supply of mosquito nets. The Government of a country devastated by the disease must conduct its campaign against the enemy under the generalship of the engineer and the agriculturist, rather than of the sanitary commissioner and the medical scientist. To the latter all credit is due and has in Italy been accorded for the discovery first made in that country of the true cause of malarial fevers. But the expulsion of the pestiferous insect from the land requires the whole machinery of the State and the co-operation of the entire population to be brought into action.

In an interesting report of 1903, the first of a series of which a second is to be issued shortly by the Italian Parliament, a description is commenced of all the "*Bonifiche*" (works of *Bonificazione*) in progress at the date of the report. It is prefaced by a brief but instructive history of the running fight against malaria during recent centuries. It shows how from the first a careful study and analysis were made of the conditions under which malaria prevails, and how closely they have coincided with the very conditions which medical discoveries have now shown to be necessary to the existence of the mosquito. As usual, popular and even medical prejudices were opposed to some of the measures taken by the State engineers to eliminate pestiferous conditions. Against none, perhaps, was more strenuous opposition raised than to the piling up of river silt, the decaying matters in which were, it was contended, a dangerous source of the malady. But the engineers persevered, and later medical science has now proved them to be right.

Bonificazione "sovereign remedy" against malaria.

10. Perhaps the fact that the creation of thousands of square miles of fertile agricultural lands has been a natural sequence of the campaign against the disease may be considered to justify in this report a notice of some of the more interesting portions of the Parliamentary preface.

After a description of the ineffectual efforts of the individual peasant and the whole corps of medical scientists to eradicate, however much they might alleviate the disease, the following statement is made of the conditions which observation had ascertained to prevail in malarious regions :—

(1) That there were in an affected locality or its neighbourhood marshy or wet tracts.
(2) That malaria is independent of the composition of the soil.
(3) That the pestiferous focus is localized, but that malaria spreads round it horizontally.
(4) That malaria does not rise vertically to any great elevation.
(5) That it prevails in the hotter months of the year—from late spring through the summer to early autumn.
(6) That the infection is more common at the rising and setting of the sun and in the early hours of the night.
(7) That salt waters are inimical to malaria.

Then after a brief account of the medical investigation of the disease ending with the discovery of the mosquito as its cause, it is shown how all the conditions, empirically ascertained, are exactly those which favour the prevalence of the pestiferous insect, and how the new "school of medicine" welcomes the *Bonificazione* of which the deposit of river silt is a main feature, as the "sovereign remedy" *(rimedio sovrano)*, obliterating as it does all the conditions under which the mosquito can live, "*at the same time that it is financially beneficial.*"

Bonificazione now in progress : 3 classes.

11. The illustration given by the history of the Chiana valley of the magnitude of the operations carried out in past centuries, may now be supplemented by a brief account of the greater work that has been done by the State since the "Unification of Italy."

It should in the first place be understood that *Bonifiche* are at the present date practically divided into three classes :—

(1) Those conducted entirely by State agency.
(2) Those conducted by private agency with some assistance from the State.
(3) Those conducted by private agency alone.

From 1862, when the period dealt with commenced, various regulations have been enacted under which the Government, on the ground of improving sanitary conditions, has been able to acquire the control of private lands during the currency of operations, and under which also the financial arrangements between the Imperial Government, the Provincial authorities and the individual owners are determined. An interesting resumé of corresponding legislation in other countries in Europe is given in the preface of the 1903 report followed by a history of Italian legislation terminating with an Act of 1900. This Act gives to the State the right of undertaking the *Bonificazione* of all low-lying and marshy lands, "the exercise of the right being on public ground justified by the necessity (1) of lessening the difficulties of police supervision, (2) of removing the causes of malaria." The *Bonifiche* are then divided into two "categories"—the first including "works of drainage and silt-building," which are designed both for important hygienic and agricultural improvement, others of minor importance being relegated to the second category. So far as can be understood, the division between the two classes is arbitrary and decided by the State in accordance with the relative magnitude of the works.

Expenditure on works how divided.

12. Expenditure on works of the first category is divided in the following proportion :—The State pays $\frac{6}{10}$ths; the province $\frac{1}{10}$th ; the commune $\frac{1}{10}$th ; the proprietor $\frac{2}{10}$ths.

Works of the second category are those in which private interest is (*a*) predominant, (*b*) exclusive. In the former case, if any hygienic or agricultural benefit at all can be proved, the State may at its own discretion grant $\frac{1}{10}$th of the expenditure and the province and the commune each another $\frac{1}{10}$th.

In case (*b*) where the interest of the proprietors is not accompanied by public advantage, the province and commune are not precluded from granting subsidies, provided that the amount advanced may be recovered on the completion of the work.

In all cases under both categories the enhanced value *(plus valenza)* of the land accrues to the proprietors, subject, it is understood, to proportionate enhancement of the ordinary land tax of the country.

Cost and area of works in progress.

13. Turning now to the cost and area of the works in progress, the only statistics available are : (1) a return of expenditure from 1862 to 1904 given in a report drawn up by the Public Works Department for the Milan Exhibition, and (2) a return in an appendix to the Parliamentary report of 1903 of the area dealt with up to date, as well as of the area still to be completed in every work then in progress.

In the report for Milan the expenditure in the 42 years on *Bonifiche* is shown to have been 221 millions of lire or nearly nine millions sterling, equivalent in Indian currency to 1,150 lakhs of rupees.

In the Appendix of 1903 the area already dealt with in works then in progress is given as upwards of 4,500 square kilometres, equivalent to something more than 1,800 English square miles, and the area still to be completed as nearly 7,000 kilometres, or 2,500 square miles. Thus the total area of works now in hand is about 4,300 square miles. The actual number of separate projects, including those into which larger schemes are sub-divided, is 249.

It is impossible to estimate the areas dealt with in earlier centuries; but on the assumption, which is believed to be on the safe side, that it was not less than 3,000 square miles, the total area which will have been reclaimed in Italy must be not less than 7,000 square miles and may be considerably more.

It may be added that schemes are in hand for the *Bonificazione* of about three-fourths of the island of Sardinia, and that these contemplate reclamation mainly by the deposit of river silt.

Which is best, drainage or silt deposit?

14. The question will be asked how much of the reclaimed area in Italy has been due to (*a*) drainage, (*b*) silt deposit. It cannot be answered with any precision, for there are no statistics. As already stated, the *Bonificazione* of the earlier centuries is asserted to have been effected by silt deposit, but in recent years drainage has assumed a predominant position. Briefly, it may be stated that while the engineers have, in later times, been disposed to favour drainage, the agriculturists advocate the silt system and the question has now for some time become the subject of acute controversy.

The main argument in favour of drainage is the comparative quickness with which results can be achieved, but it is contended on the other hand that such results are far less satisfactory than those secured by the raising of the soil. The mere lowering of the water level seldom leaves the land entirely free from unwholesome depressions and never exposes land of anything like the same agricultural value as that which is composed of fertile silt.

The question was discussed as recently as 1904 at an Agricultural Congress at Ravenna, near which place extensive reclamations by both methods are in progress. After an address by Professor Niccoli the following resolutions were unanimously carried :—

(1) That no absolute rule can be laid down—local conditions must guide a decision.

(2) That putting aside other considerations, *it is "a grave error" not to profit by fertile silt whenever it is available.*

(3) That in many cases both systems can be applied—that sanitary conditions should be secured as soon as possible by temporary drainage; that they should be supplemented by gradual silt deposit.

(4) That a corps of agricultural engineers should be trained who would be competent to deal with both engineering and agricultural operations concerned.

Here we may leave the question. The conclusion at which I have myself arrived after discussing the arguments *pro* and *con* with many of the agricultural authorities, as well as with engineers engaged in practical operations, is that the third resolution of the Ravenna Conference points to the wisest course and one which is in best accordance with the views of those most competent to give a sound opinion.

Necessity for corps of agricultural engineers.

15. A few words may be added on the subject of the fourth resolution. There is no doubt that, as pointed out by more than one Italian writer of authority, the instinct of the engineer is in favour of a rapid system of which every operation comes within his professional capacity, whereas he has not acquired by his training a full sympathy with agricultural interests, especially when they impede the progress of his work. On the other hand, the staff of the agricultural departments have not, in Italy, had any sufficient training in either scientific or practical engineering. The reform suggested is that as in Germany, whose example has been followed in other continental countries, a corps of agricultural engineers should be raised, competent to deal with the many operations in which an engineer can serve agricultural interests. The subject will be further noticed when dealing with Indian conditions in a later section of this report.

Financial results of *Bonificazione*.

16. The question may now be asked, what is the commercial aspect of *Bonificazione in the plains?* Does it yield profit or loss? It may be at once said that the Italian Government has undertaken its campaign against malaria without regard to financial results. The evil is so great that it must be eradicated at any cost. And there is no doubt that some schemes which were begun with imperfect knowledge and experience and which were interrupted by the political troubles of the country have cost more than they are financially worth. One of the items which has most seriously affected the debit columns has been the compound interest accruing on the compensation awarded under earlier Regulations to proprietors whose lands were temporarily purchased by the State. But in the two most extensive works

which I visited, and in each of which some hundreds of square miles had been built up with river silt, the engineers were unanimous in declaring that if what is known now had been known when the work began, the projects could have been carried out in half the time with highly profitable results. As it is, in one section of something like 100 square miles it was made out that there had been a profit of over 20 per cent. Not unnaturally cases in which extraordinary rise in value has occurred are prominently quoted as proof of the financial success of the silt system. A tract, for instance, near Capua of about 1,000 acres, valued at 700 francs before the operations, has now realized 50,000 francs. But such exceptional cases are no general guide. The following examples, gleaned from official reports of private works, may, however, be taken as trustworthy indications :—

At Grosseto cost was 503 francs per hectar (2¼ acres), value of hectar raised from 290 to 457 francs.

In the Florence Province cost was 457 francs per hectar, value of hectar raised from 700 to 2,000 francs.

At Capua* cost was 235 francs per hectar, rental value raised from 75 to 300 francs.

At Ravenna cost was 577 francs per hectar, increase in selling value 721 francs.

At Brescia cost was 800 francs per hectar, increase in selling value 1,000 francs.

The large number of cases in which private owners are now carrying out the silt system, with or without some assistance from Government, is significant in view of the fact that in such cases the sole object is financial advantage.

Much, of course, depends on the amount and value of the silt which the river carries. Very careful analyses are accordingly made by chemical experts of silt taken from each river, especially when in flood, at various depths. From some rivers, as at Ravenna, the silt is only worth taking immediately after heavy rains in the hills, which perhaps only occur six or seven times in the year, and even then the deposit of the silt is confined to a few hours on each occasion. The river Volturno, on the other hand, near Capua is much richer in fertile silt and can be utilized much more often and for longer periods. Progress in the former case is much slower than in the latter.

Methods by which silt is deposited.

17. The pen of an engineer is required for a description of the systems and methods by which silt is deposited. More than 50 pages are devoted to the subject in one of Professor Niccoli's treatises. Many factors have to be considered—the slope of the ground ; the character of the silt ; the depth of the required deposit ; the time allowed for the completion of the work ; the drainage system of the locality. I can only venture to indicate in Appendix A attached to this report some of the leading features of the operations.

Bonificazione in the hills by silt deposit.

18. The system of reclaiming ravines and rugged hills by silt deposit is technically known as *colmata di monte*, or building up of the hill. In the plains the term *colmata* is applied to the raising of the soil level by silt deposit ; in the hills, to the filling up of ravines and depressions with silt deposit. In the one case the silt is naturally carried by rivers to the locality under treatment ; in the other earth is more or less artificially torn from the projecting buttresses of the hill or ravine by rainfall discreetly guided. Perhaps the term "doctoring" the hills and ravines might not be inappropriate and nearer the truth than "reclamation."

A long history is attached to the development of rugged hillsides and ravines. The earliest system was the primitive practice of "terracing," such as we are familiar with in the Himalayas, each terrace being supported by banks strengthened, if need be, with bush growth or by stones or masonry. This plan has afforded no protection against the gradual erosion of soil which is torn away into the ravines by heavy rains and torrents. Here again Leonardo da Vinci was one of the first with his advice to "*break the ravine torrents by watercourses branching in various directions.*" Gradual modifications, which need not be described here, were made during succeeding centuries, until about 100 years ago, when in the hills between Pisa and Florence, the land agent *(Testa ferata)* of the Marquis Rudolfi worked out a system which is described as a "*Stupenda invenzione*" and which is now accepted as the most perfect plan of dealing with ravines and rugged hills.

The general principles are first the complete control over the drainage and rainfall by a parallel series of horizontal trenches ; next the construction of parallel dams in the depressions and ravines ; finally, the conveyance of silt by slanting water-courses led into and out of the depressions behind the dams in zigzag fashion. The torrential force of the drainage is thus broken much as the pressure of a crowd is relieved by the zigzag alleys constructed at the entrance to a durbar hall.

* The estimate was given by the engineers. The other figures are quoted from reports.

The appearance of a rugged hill broken by deep ravines becomes, when thus treated, a series of level uninterrupted terraces following in subdued relief the curves and angles of the once rugged slope.

A more detailed description of the system will be found in Appendix B.

The "doctoring" of hills and ravines is effected in all cases by private landowners without the assistance of Government, and no statistics are available of the areas which have been thus treated. The most instructive examples are found on the estates of the Marquis Rudolfi between Pisa and Florence.

Section II.—In India—Present Conditions.

Advantages understood—but no organized system.

19. The main principle which underlies the work done in Italy is well understood and appreciated by most cultivators throughout India. For that fertile silt deposited on a field enhances its productive value is too obvious a fact to escape the knowledge of any tiller of the soil. But the application of the principle, requiring as it does general control over drainage and streams, is as a rule beyond the power of the individual cultivator who rarely occupies more than a few acres. Landed proprietors who, in some cases, might take useful action in the more extensive areas under their command, are too little acquainted with engineering science to undertake large schemes, while the governing authorities have not, so far as is known, yet taken the subject under special consideration. Nevertheless, here and there where exceptional facilities exist the principle has been brought into useful action with or without the assistance and encouragement of local authority. Some account of what has been done will be given in a later paragraph.

History of my own connection with the subject.

20. I may perhaps be pardoned for explaining how my own attention was first drawn to the subject. Some time after the first provincial department of agriculture was formed and committed to my charge I visited an estate managed by the late Captain Chapman on the banks of the Ganges. Captain Chapman had attempted to harness the great river for the flooding, levelling, fertilization, and watering the low-lying lands in an extensive bay below the high cliffs. It cannot be said that he did not succeed in controlling the river, although the object being the cultivation of indigo then starting on the downward grade, the scheme which involved costly machinery ended, it is believed, in financial failure. The attempt to control the lower waters was interesting enough. But what attracted my special attention was a more successful attempt to 'harness' the drainage on the summit of the high cliffs. By a system of small dams across the ravines, supplemented by terracing, silt was held up, the further erosion of the upland checked, and the letting value of the land quadrupled.

Returning to the provincial farm near Cawnpore, where now the agricultural college of the Upper Provinces is nearing completion, I took in hand a small area of broken raviny land close by and began 'doctoring' it with dams and drains much in the fashion of a boy playing with sand on a seaside beach, but was removed from the province before I had seen more than the commencement of the slow process of silt deposit. An intelligent assistant, however, who had been, by request, selected for the department as being active in the playground as well as good in the school, had watched and appreciated the proceedings and, carrying them on after my departure, eventually asked for and received permission to rent from the proprietors the broken and neglected lands of the neighbourhood, which he succeeded in transforming into a profitable estate of which the rental value has been quintupled. He is still, in 1906, extending further afield the system which has made him, after his retirement, a prosperous yeoman farmer. As long ago as 1892, my successor, Mr. Holderness, wrote to him as follows :—"*You have clearly shown that by embankment and a very moderate outlay on manure it is easily possible to improve broken and apparently sterile land and convert it into fertile fields. Until I saw your work I had not realized how valuable the simple expedient of embankment is.*"

It is true that in this case there were special advantages. The student, Luchman Pershad, had risen to be manager of the farm and had learned agriculture; the market of a large city was near at hand; manure was easily obtainable; and land once brought into good condition was valuable. But the object lesson is interesting, not merely as an illustration of the success of 'doctoring' ravines and broken lands, but also as an example of what an intelligent native can do when he has received a practical education in his youth.

Issue of circular to all Provinces.

21. I had other opportunities of observing the useful results on a small scale of preventing erosion and holding up silt, and was sufficiently impressed by the importance of controlling the drainage in extensive areas of broken land and of depositing silt in ravines and depressions to pursue the subject when transferred to the Government of India. Advantage was taken of various agricultural conferences to which provincial officers were invited to discuss this among other questions. It was found, of course, that the leading principle was more or less well understood

in every part of India, but that its application had never been brought under any co-ordinated scheme. It seemed desirable, however, to ascertain more precisely what had been done in each province in the required direction, and I was in 1893 permitted to issue a circular asking "what was the prevailing practice, or what action had been taken in constructing dams for other purposes than irrigation with the object (*a*) of preventing erosion, (*b*) of fertilizing land by deposit of silt."

The circular was accompanied by a copy of the account given by Sir Colin Scott-Moncrieff of the fertilization of land by silt deposit in the south of France to which reference has been made in the third paragraph of this report.

Replies to the circular.

22. The replies to the circular are brought together in the 'Agricultural Ledger No. 2 of 1897' and form interesting reading. When, however, I left the Department in 1894 there were no funds available for suggesting any Imperial scheme, and the only action which could be taken up to that date was the recommendation circulated with the Famine Code to utilize works of the character indicated as 'famine relief works.'

A brief summary of the replies to the circular is given in Appendix C from which it will be seen—

(1) that the principle of utilizing silt is appreciated throughout India;
(2) that the application of the principle compared with the possibilities is insignificant and as a rule of petty character;
(3) that no schemes for the control of drainage for the purpose had been up to that time undertaken by the State.

Thus, to quote from the first reply, that of the Madras Government: "The agricultural classes are well acquainted with the beneficial results of silt deposit; official grants have in a few cases been made for construction of works to control drainage; agriculturists erect them when profitable; but erection of works for express purpose of silt deposit is exceptional and confined to four districts."

Again from the Upper Provinces the Agricultural Director writes that in the Himalayan and Sub-Himalayan districts, where such measures as those described by Colonel Scott-Moncrieff might be possible, embankments except for irrigation and prevention of flooding are unknown, and names thirteen districts in which "no practice of the kind exists."

The regions where the agriculturists take most action appear to be in some parts of the broken country of the Central Provinces, including the adjacent districts of Bundelkhand within the Upper Provinces, and again towards the North-West Frontier and the Indus.

Occasional assistance is afforded here and there by the local authorities, mainly by advances for the construction of embankments, to those agriculturists who desire to manure their fields with silt deposit. But nowhere is any general control of the rivers and drainage for this purpose exercised by any State Department.

Section III.—In India—Possibilities.

Text in Italy, Economic error not to utilize silt.

23. The text upon which Leonardi da Vinci and other great economic leaders in Italy preached in the earlier centuries was that the utmost use should be made of the manure which nature offers in the silt of her rivers and streams. The same text was adopted in the Resolution of the Ravenna Conference, already quoted, in 1904—"*It is a grave error not to profit by fertile silt whenever it is available.*" Should not the same text be adopted in India?

Manure, next to water, the greatest agricultural need of India.

24. It is doubtful whether in any country in the world the adoption of this text and its application is more needed or perhaps more feasible than in India. The one great crying want of agricultural India is manure. It may be said that water is its first great need. Even if this be admitted, and it is only true of some regions, the answer is that almost everything possible has been done by the agriculturists and is being done by the State to satisfy this need. But water alone does not suffice. It has indeed been proved, in the evidence quoted in a history which I was called upon to write of canal irrigation in India, that pure water tends to actually impoverish land which cannot be refreshed by an adequate supply of manure.

Expanding supply of rich manure obtainable in river silt.

25. A constantly reiterated charge against the agricultural system of the country is that the three most valuable manures which elsewhere are employed for the fertilization of land are either exported or burned. These are bones, oilcake, and farmyard manure. The first two are exported for agricultural use in Europe, the last is, except during the rains, dried and burnt as fuel.

The application of artificial and chemical manures imported from outside has been made the subject of experiment on Government farms and planters' estates. The result is that they are found too costly for general use and liable also—many of them—to be washed out of the ground by heavy rains.

It is difficult to see what other manure supply not yet drawn upon is available for India other than the fertile silt of its rivers, streams, and drainage.

Agricultural geography of India.

26. It may be useful in reading what follows to open the three maps in the Statistical Atlas of India which give a 'bird's-eye' view of the drainage system, the geological formation, and the density of population in India. The last is added because no quicker indication of the fertility of a region can be given than the population which it supports.

The general conclusions which may be drawn from a brief study of these maps are :—

I. That the 'washings' from both sides of the Himalayan range are brought by the drainage system into India. The Indus and Brahmaputra rise close together on the other side, while the great rivers on this side flow over or through the Punjab, Upper Provinces, and Bengal.

II. That there is a great alluvial plain of which one branch on the east, slopes from the Punjab to the Bay of Bengal, and the other on the west, to the Arabian Sea. These may be termed the Indus branch and the Ganges branch respectively. There is no reason to doubt that the upper strata, at any rate, of these great alluvial plains have been formed by silt deposit carried by the drainage of the Himalayan range.

III. That alluvial soils have been deposited by the drainage from the hills of Central and South India both on the sides and at the mouths of the rivers, as well as along the western base of the mountain wall that receives the brunt of the summer monsoon.

IV. That the most densely populated, and therefore the most fertile, regions are those of silt deposit, the population becoming most dense towards the river deltas.

Erosion by rivers.

27. It hardly needed this scanty survey of the alluvial deposits in India to indicate that the richest agricultural land is fertile silt, but there are two considerations to which it leads which are not clearly exhibited by the maps. One is that the better soil has been gradually washed from the upper portions of the sloping alluvial plains to the lower portions. Thus we find sand dominating in the Punjab ; loam, or mixture of sand and clay, in the Upper Provinces ; and clay in Bengal. The other is that the Himalayan rivers which must once have built up with silt deposit the upper plains of the Gangetic valley have now cut deep channels in the very plains which they originally formed, and not only cease to fertilize them with fresh deposit, but actually erode and gradually but continuously carry away the silt which they once laid on them—being assisted in this work of destruction by the numerous feeders which are cutting more deeply every year into the rich layers of deposit and carrying the most fertile elements of the old silt into the Ganges, Jumna, and other large rivers. The same remarks apply, *mutatis mutandis*, to the drainage system of many other parts of India.

Desirability of preventing erosion and of utilizing silt.

28. The above considerations lead to the conclusion that two objects have to be held in view—(1) the prevention of further erosion ; (2) the arrest and utilization of fertile silt. In other words, we have to prevent the gradual loss of fertile silt deposited in past ages, and to superimpose on the silt already possessed a fresh supply.

Control of drainage necessary.

29. To effect these objects the first thing necessary is the control of drainage—the 'harnessing' as the Italians put it—of the rivers and streams. Whether to supply silt, or to arrest loss of silt, drainage must be brought under complete control. And since, of the two objects, the deposit of fresh silt is the most important, it may be desirable to bring it under first consideration.

Fortunately the larger rivers which wash and drain the inner slopes of the Himalayan range have been already 'put into harness' by the genius and ability of our engineers. But so far they have driven them only towards one goal, the one, it is true, of supreme importance, *irrigation* or the supply of water. The question now to ask is whether the harnessed waters can be driven to that other goal of second but also of grave importance, *fertilization* or the supply of manure. It is a question which only our great engineers, and happily we possess them, can answer.

A corollary to the problem is whether, independently of the already harnessed rivers and streams, other drainage waters which now carry away that useful manure which 'it is a grave error not to utilize' can be likewise arrested and made to deliver the wealth that they contain.

The presumption that a favourable answer can be given to these questions seems to be afforded by the fact that the comparatively feeble attempts of untrained agriculturists throughout India to arrest and utilize silt with little or no aid from professional agency have succeeded in many localities to solve the problem on a

small scale. To attempt its solution on a large scale State action and high engineering science are essential.

Analysis of value of silt in each stream necessary.

30. But before the important problem is referred to the engineer a preliminary issue has to be examined by the agriculturists. It is first necessary to ascertain what is the value of the manure which is carried, or rather carried *away*, by each river stream, or drainage channel. The evidence afforded by the replies to the Imperial circular sufficiently proves that in many cases the manure is of high value. More than once it is written that 'no other manure is wanted.' But there are some streams of which the silt has little or no fertilizing property. And in the case of all streams the silt carried is only worth taking occasionally for very limited periods. Thus in the neighbourhood of Ravenna in Italy, where the proprietors are keenly building up new plains of fertile silt, the river is only turned on to the land immediately after heavy rains in the hills (an occurrence which takes place but six or seven times in the year), and then only for a few hours on each occasion. At other times the silt is not worth using. On some other rivers the agricultural chemists are required to analyse the silt taken every hour or two from various depths of the stream, in order to ensure the utilization of the most valuable stratum of the water.

It is, however, satisfactory to find that the recent analysis of waters in the Sub-Himalayan region when the rivers and canals were flooded by the earlier rainfalls gives in many cases promise of a supply of fertilizing silt. Five of these analyses were sent to Italy and submitted to the professional experts of the Milan and Pisa Universities who pronounced favourably on the agricultural value of at least three of the five, and out of the three it is worth noting that two came from waters already harnessed in our canals. The analyses of other samples have been since submitted to the Government of India, the value of which can be gauged by our own agricultural chemists, but from a cursory examination of them the conclusion seems permissible that many of them contain fertilizing matter of importance.

Working plans necessary.

31. When the agricultural chemists have made their examination of the silt it would be for the engineers to ascertain whether or in what way fertilizing water can be carried on to the land. It may be presumed that, if the State should decide to take any action, 'Working-plans' would, as in the case of the Forests, be drawn up for each tract which it may be designed to take under treatment. It need hardly be said that in every case a preliminary examination of the levels and of the agricultural conditions of the land, in which enquiry the agricultural officials would perhaps be associated, would have to be made before a 'Working-plan' could be outlined. But this report is hardly the place in which to suggest further details. Its primary object is to gain, by presenting the object lesson afforded in Italy, an appreciation of the leading principles which have secured such an important extension of fertile land in that country. The application of them if attempted in India must be worked out by experts more competent to deal with the subject than the writer.

Study of Italian methods by our engineers desirable.

32. If further action is to be taken the suggestion may be respectfully submitted that one or more selected engineers should be deputed for a short period to Italy to study the methods adopted in that country. It has been ascertained that arrangements can be made which would ensure their being accompanied by an expert official, well acquainted with English and with the agricultural conditions concerned. It may be conceded that our own engineers are inferior to none in the control of rivers, streams, and drainage. But it may be also remembered that the developments of the system with the direct object of fertilizing land in Italy have been worked out in the course of centuries by the best brains in that country and it would seem a 'grave error,' to repeat the words of the Ravenna Resolution, not to study the conclusions at which they have arrived. It could have been wished that a complete account of Italian methods could have been given in this report, but it will be readily understood that, in detail, they can only be efficiently examined and described by professional experts.

Drainage maps required —simple system suggested.

33. One measure might however be taken independently of engineering operations. The first essential for Working-plans is a series of drainage maps for each district or tract showing how rainfall is carried by depressions and minor streams into the larger rivers. It became my duty as settlement officer in the N.-W. Provinces to work out a system by which such drainage maps in great detail were prepared practically without cost. The system has since been adopted in the Canal Department and was described by a late Chief Engineer of the Department as superior to maps professionally prepared by level surveys. An account of the system is given in Appendix D.

Prevention of erosion.

34. Turning now to the second agricultural object of controlling drainage, *viz.*, the prevention of erosion, *i.e.*, of the removal of fertile soil, allusion may be, as before, made to the encour-

aging success of the efforts by agriculturists, with or without official aid, to arrest the progress of erosion in some localities. But here again schemes of importance can only be carried out by the State or under State direction. It is doubtful indeed whether the extent to which the soil of agricultural land is being gradually removed is appreciated by any but the local officials whose duties lie in those regions which are being eaten away. It is believed, to give one example, that some hundreds of square miles have in the course of ages been eroded by the Jumna and its tributaries in the Upper Provinces, and that the process still goes on without check.

The replies quoted in Appendix C indicate similar destructive action in other parts of India.

Restoration of eroded areas to fertility.

35. But the prevention of erosion may, and in many cases must, go hand in hand with the restoration of the broken surface to fertility by deposit of silt and earth in the ravines and depressions, as well as by terracing. An important consideration in the case of broken country on the banks of large rivers is that much of the silt carried down ravines is derived from good agricultural land. A successful example on a small scale of this class of work at Cawnpore has been already quoted and other illustrations are supplied in the replies to the circular. It is in this direction that the system developed in Italy may be usefully studied and should, if the suggestion of sending professional experts to that country be accepted, be professionally examined.

Suitability of work for famine relief.

36. There is no class of works which in the opinion of the writer is better suited for famine relief. It was so suggested in the first edition of the Famine Code. But the suggestion has, it is believed, never received serious attention until the present year (1906-07) when several lakhs have been awarded by the Bombay Government at the instance of the Honourable Mr. Muir-Mackenzie, Member of Council, for this class of work. One of its advantages as a famine work is that it can often be executed on the raviny banks of large rivers where a supply of drinking water for the famine coolies is easily obtained.

It is evident, however, that if such work can be utilized for famine relief, large schemes should be carefully prepared by professional engineers after a close study of the local conditions and drainage system.

Need of trained agricultural engineers.

37. All that has been written points to the desirability of following Italy in suggestion for a corps of agricultural engineers. Granting that the preparation of large schemes, and even the inauguration of smaller ones, requires the best talent available in the Public Works Department, yet the system once applied is one which can be learned and put in operation by native engineers properly trained for such work. It is perhaps hardly the place to point out that there is a great deal of other work useful to agricultural interests which can be efficiently carried out by a trained native engineer in almost every district of many provinces, such as well construction, boring for wells, the introduction of agricultural machinery, and so on. But no agricultural objects could be more desirable than those of preventing the loss, and increasing the quantity of fertile soil. The success at Cawnpore of restoring to fertility and arresting further loss in something like 500 acres of broken land is due to the intelligence and energy of a trained native single handed. A note on the subject of training agricultural engineers in Germany and France by Professor Giglioli of the Pisa University who, himself trained at Cirencester, has been for many years in charge of agricultural schools in Italy, and who during the last Paris Exhibition prepared for the Italian Government a comparative exposition of the agricultural systems of all European countries, is appended to the Report (*vide* Appendix E). Coming from so eminent an authority it should carry weight.

Mitigation of malaria.

38. The hygienic advantages of raising the level of soil in depressed tracts by the deposit in them of fertile silt must not be overlooked. It may be noted that in Italy it is not merely tracts on the borders of the coast that have been raised above what may be called the mosquito level. The extensive valley of Chiana, some 800 square miles in area, which has been raised almost entirely by silt, lies well inland. But it is difficult to predict how far sanitary results can be expected in the inland regions of India. The existence of the malarious Terai at the foot of the Himalayas naturally leads to the question whether its sanitary conditions can on the Italian plan be improved. But the peculiar character of the drainage system there, complicated by irrigation channels, may impede its amelioration, and it can only be suggested that the question should be considered by those more competent to deal with it than the writer. At the same time there must be many unwholesome depressions elsewhere which could be hygienically improved by silt deposit. The present tendency is, it is believed, to drain such depressions, but the objections to that course are that in some cases complete cure is not effected, and that in others

there is a danger of lowering the subsoil water level from which wells are fed. The successful results which have been achieved in Italy seem, however, to merit a serious consideration of the question how far it may be possible in India to reduce the malarious conditions of many parts of the country by the agency of silt deposit.

Summary of suggestion.

39. The suggestions for early action in India may be thus summarized :—

(1) That a competent engineer (or engineers) should be deputed to Italy for professional study of and reports on Italian methods.

(2) That the subjects dealt with in this report should be discussed at the Agricultural Conference to be held at Cawnpore in February 1907.

(3) That measures should be taken for preparing drainage maps in the system described in Appendix D. Such maps will be useful for other purposes.

(4) That analyses should be continuously made of the silt in selected rivers and canals.

Questions for consideration in later years are :—

(5) Whether the silt of Indian rivers and canals, especially in Sub-Himalayan tracts, can be profitably utilized.

(6) Whether notoriously unhealthy tracts, such as the Terai, can be treated on Italian methods, for the checking of malaria.

(7) Whether schemes can be prepared for inclusion in famine relief programmes.

(8) How far existing canals can be utilized for the distribution of fertile silt.

APPENDIX A.

Methods by which in Italy silt is Deposited.

As a rule the tract under treatment is divided into definite sections or blocks, generally rectangular, of which the area may vary from an acre to even square miles. In two typical cases before me the blocks in one are about an acre each and in the other from 100 to 200 acres each. Every block is surrounded by a bank strong enough to hold in the water.

In some cases a river, in others a canal led from the river, is turned into the block, now at one opening and then at another as convenient, whenever the river is in sufficient flood to be loaded with silt.

If the slope of the land is slight, it is considered advisable to begin from the lower blocks or lower portions of a block and work upwards in order to prevent the silting up of the inlets ; if the slope is material, to begin above and work downwards so as to bring the higher lands under cultivation as soon as possible. In some cases the whole of a very large area is covered at one and the same time with silt-laden water.

The methods of letting off the water or ' decanting ' as it is termed, vary. Five are noted : (1) to allow the water to evaporate and be absorbed ; (2) to run off the water by escape channels as soon as it is clear, and then if the river still bears silt to run in a second supply ; (3) to run off the water when only part of its silt is deposited ; (4) to run it off by degrees as the upper strata become *completely* clear ; (5) to run it off by degrees as the upper strata become *partially* clear.

The first is generally condemned, partly on account of the delay involved. The second and fourth systems are imperative where the local regulations forbid any but clear water being turned into the escape channels in order to prevent clogging of the drainage. The third and fifth systems are advocated when the deposit to be laid is of material depth, say more than 8 inches. It often exceeds 3 feet. In such cases it is an advantage that the lower strata should be composed of the heavier and more permeable deposits, but in all cases the upper stratum should consist of the finer and more fertile silt, and when this is being laid the water should issue clear from the outlets. Another point for consideration is that deep water should not rest long on the land which would be pressed and unduly hardened by its weight.

Contrivances have been developed for tapping the river or canal, of which some no doubt would be of the same character as those familiar to our canal engineers. They vary with the area of the blocks and the volume of water to be dealt with. These, as well indeed as all the practical methods employed, should, if they are to be imitated, be subjected to study on the spot by a professional engineer.

APPENDIX B.

System of 'doctoring' Hills and Ravines.

The 'Testaferrata' system is described in a treatise by the grandson who has succeeded to the Rudolfi marquisate; also by Professor Niccoli who devotes 40 pages to the subject; and more elaborately still by an agricultural professor, Conti; in each case with the aid of explanatory diagrams without which indeed it is difficult to give a clear account of the methods employed.*

The following general remarks taken with little modification from Niccoli's 'Agricultural uses of water' may be useful:—

"The building up of the hill (*colmate di monte*) have for their complex object the utilization of the force of the waters for the removal of the objectionable ruggedness, whether convex or concave, and for modifying or making more uniform the slopes. The waters act in two-fold manner—(1) by eroding the projections and convexities and carrying away earth from them; (2) by transporting and spreading the silt into depressions and concavities. The hills which lend themselves most readily to the system are those with rounded summits which supply a sufficient amount of rain water to the ravines . . . . . The first thing to do in order to prevent disastrous erosion is to surround the upper portion of the hill or slope with a trench succeeded lower down by similar horizontal trenches from which streams are conducted in any required direction. This is in effect the principle preached by Leonardi da Vinci in the chapter quoted in paragraph 1 of this report." Professor Niccoli then enters into technical calculations which show that in a hectar of land (2¼ acres) with a slope of 150 feet 30 inches of rain in the year will give a force equal to one horse-power working for 150 days in the year. "The object is," he adds, "to use this natural force, by guiding and directing it, for levelling the ruggedness of the hill."

The preliminary treatment of the hill above indicated is then supplemented by what we may call the 'doctoring' of the ravines and by protecting the base of the slopes. For the latter purpose a large trench is carried round the foot of the slopes. Next dams are carried across the ravines above the horizontal trenches and gradually raised as time goes on. The framework is thus arranged in a manner which gives control over the drainage. Finally, small channels are led diagonally at steep inclination from the upper horizontal trench to the ravine hollows behind each dam. When rain falls, water, laden with soil, is carried diagonally into the hollow above each dam and allowed, when clear, to issue on the other side. Here the issuing stream is joined by the diagonal earth-laden feeder from the ditch above, and the waters of the two joining together are carried into the hollow above the next lower dam. The issue is made, after deposit of silt, from the opposite side, and thus the drainage, of which the torrential force is broken, is carried in a zigzag fashion, with halts behind each dam, to the main trench at the foot of the declivity.

If there should be uneven land more horizontal in character at the base of the slopes, it may be levelled by silt deposited by the drainage, now completely under command, on a system similar to that adopted ordinarily in the plains.

[* M. Conti. La sistema e lo scuolo delle acquè dei terrini di collina (Casale 1903).]

APPENDIX C.

Summary of Replies to the Circular of 1893.

The replies to the circular bear out what has been said in the report as to (1) the appreciation by cultivators of the advantage of silt deposit; (2) the sporadic and disjointed character of both agricultural practice and official action, and (3) the absence of any co-ordinated programme. Perhaps the first reply on the list from the Madras Presidency may be taken as a suggestive sample. "No action has been taken of late years to promote construction of dams for the purpose of preventing erosion or for fertilizing land by deposit of soil. There is little or no definite information regarding the practice of ryots. They are in the habit of making small dams to prevent erosion or in rice fields to bank in water for deposit of soil."

After further information had been called for and received, the Government of Madras could only add that in a few cases official grants had been made for such works with the beneficial results of which the agricultural classes are well acquainted, and they construct them when profitable. But their erection, it is added, for the express purpose of silt deposit is more or less exceptional and confined to four districts. In the hills, slopes are protected by terracing and side drainage channels.

In Bombay salt land reclamation by silt deposit is common, but requires large capital. Field embankments are elsewhere made with the primary object of preventing erosion, but incidentally hold up silt. "No special action had been taken by Government," but advances had not uncommonly been made by district officers for embankments. [*This position is now modified by the grant in* 1906 *of several lakhs for preventing erosion as famine relief work*].

In Bengal no Government action had been taken. Cultivators had in a small way and sporadically, formed or enriched rice-fields with silt deposit. The agricultural officer who reported (Mr. Basu) had written a special report on the subject in 1885, published by order of the Secretary of State, and expresses his opinion that there is "no other work in which moderate amounts of capital can be so profitably invested."

In the North-Western Provinces some official action had been taken (partly, it is believed, at my own instigation) near Jhansi, and generally in Bundelkhand advances had been given for the purpose. Something had been done, too, here and there in Court of Wards estates, sometimes with success, but often with failure, due apparently in measure to imperfect construction. As elsewhere, control of drainage on a petty scale is exercised in some parts of the Provinces by cultivators and land-owners. One report from Bundelkhand states that the value of the land is sometimes raised ten times.

Another officer writes that the effect of silt deposit is marvellous. A significant remark is made by the Director of Agriculture that in the Himalayan and Sub-Himalayan districts where such measures as those described by Colonel Scott-Moncrieff might be possible, embankments except for irrigation or prevention of damage by flood are almost unknown, and 13 districts are named in which "no practice of the kind exists."

In the Punjab 'reclamation' works are reported from the Indus primarily for irrigation but incidentally inducing silt deposit, and terracing is reported from the Salt Range, but no notice is taken in the Punjab summary of action in other districts, though such action is understood to be not altogether wanting.

An important paragraph occurs in the Dera Ghazi Khan report which states that "the water of the hill torrents is thickly charged with silt and a depth of from 3 to 6 inches is often deposited. This is most fertilizing and takes the place of manure."

In the Central Provinces petty embankments, especially for rice lands, are not uncommon and are encouraged by the Government.

In Assam some control of drainage is exercised but mainly to prevent flooding.

In Burma only in one district, Pegu, is petty and isolated action taken by cultivators to utilize silt deposit.

An interesting circumstance in the Gwalior State, not alluded to in the replies, may be worth mentioning. There Colonel Pitcher when in charge, collected the drainage waters of one or two square miles, in some cases more, and focussed them to a dam which held up the water for the irrigation of rice below. When the water was 'decanted' it was found that poor as the land was from which the drainage came, the silt deposit above the dam gave magnificent crops of wheat.

APPENDIX D.

Construction of Drainage Maps.

The method adopted by me first of all in 1870 when Settlement officer in the Furrakhabad district for the construction of drainage maps was the following :—

It was the duty of every patwari (village record-keeper) to mark on each field in the map by symbols or figures the nature of the soil, the rate of rent, character of irrigation, and so on. He was required to add an arrow, *showing the direction in which rain-water flowed out of the field.*

The village maps were then examined by supervising clerks instructed for the purpose who combined the field arrows into broader arrows showing the main drainage lines which carried the rain-water out of the village.

When the village maps were placed alongside each other the drainage lines of any given tract could be easily drawn.

The late Mr. F. N. Wright was then about to commence the mapping of the whole of the adjoining district of Cawnpore. He took up my method and produced at practically no cost an admirable drainage map of the whole district. I have not however been able to procure a copy and fear it may have been lost. But a section of it embracing about a fifth of the district will be found in a " Note on Reh (saline efflorescence) " where it was inserted in order to exhibit the connection of Reh with the drainage system.

In 1878, the Engineer attached to the Agricultural Department of the North-Western Provinces, of which I was the Director, was Captain Clibborn, who subsequently became, as Colonel Clibborn, the Principal of the Rurki Engineering College. In that capacity he published a manual on canal construction in which he prescribed the field arrow method as the simplest, cheapest and most effective method of preparing drainage maps.

The system could be adopted without difficulty throughout the greater part of India wherever indeed village maps exist. Such maps would be useful for many purposes, both in the Agricultural and Public Works Department.

APPENDIX E.

NOTE BY PROFESSOR ITALO GIGLIOLI, DIRECTOR OF THE AGRICULTURAL SCHOOLS AT THE PISA UNIVERSITY, ON THE TRAINING OF AGRICULTURAL ENGINEERS.

UNIVERSITA DI PISA.

January 18th, 1907.

When the higher agricultural teaching began, about 1840, in consequence of the teachings of J. Liebig, and Agricultural Colleges were instituted in England and in Germany, or connected with University teaching, in Scotland, in Germany and in Italy, the prevailing idea was that the essential teaching of agricultural sciences was to be of a chemical and botanical nature, besides the teaching of the practice of agriculture and of the breeding of farm animals. In countries, such as those of Northern Europe, having an abundant rainfall, and with a fair distribution of rain during the different seasons, the questions connected with the economy and distribution of water to the crops, were secondary in respect to the other questions regarding the feeding of crops. Thus, it was thought that the reclamation of waste land, and the making of agricultural land, were questions not connected with purely agricultural teaching.

In Italy, or rather in Lombardy, the higher supervision of agriculture has for many generations been in the hands of Engineers specialised in all questions connected with irrigation. But the movement for giving to higher agricultural teaching the character of *agricultural engineering* began in Germany and Austria, and has been followed in France and in Belgium. In this reform the training of an Engineer is considered necessary as forming the basis of a higher agricultural teaching, the Engineer becoming specialised in the agricultural sciences [agricultural chemistry, physics, agricultural botany and pathology, agricultural bacteriology, etc., etc.], and in the practice of farming and of the breeding of farm animals. In agricultural engineering, great stress is laid upon the study of hydraulics and of all questions connected with the distribution and management of water in connection with agriculture; special importance is also given to the study of mechanics in connection with agricultural machinery.

The beginning of this reform in higher agricultural education is very well described in the Report by the late H. M. Jenkins, written in 1884 for the Royal Commission on Technical Instruction, and published in that year in London, by Eyre and Spottiswoode. I include an extract from Mr. Jenkins' Report on Agricultural Education, regarding the introduction of agricultural engineering in the Agricultural Academy of Poppelsdorf, near Bonn, then under the direction of Dr. Dünkelberg, the well-known hydraulic engineer. The effects of this reform in the higher agricultural teaching in Germany have been well described in a Report published by L. Faure, in 1898: L. Faure: *Irrigations, Drainages, Assainissements et autres ameliorations foncierès en Allemagne et dans quelques pays de l'Europe centrales*. This Report was published in the *Annales de l' Institut National Agronomique de Paris*. XX^{me} année, 1892-96 [Paris, 1898]. The Institut National Agronomique de Paris was also reformed about that time, and now prepares agricultural engineers.

It is self-evident that in all countries subject to frequent or to periodical drought the management of economy of water for agriculture is the main agricultural question; and unless a sufficient number of experts are prepared, thoroughly acquainted with all questions connected with the management of water, with the reclamation and preparation of land and with the preservation and increase of its fertility, it is not to be hoped that agricultural progress can be ensured by the more simple forms of agricultural education.

EXTRACT FROM THE REPORT OF H. M. JENKINS, F.G.S., ON AGRICULTURAL EDUCATION IN NORTH GERMANY, FRANCE, ETC., TO THE ROYAL COMMISSION ON TECHNICAL INSTRUCTION.

(*London: Eyre and Spottiswoode*, 1884, *p.* 25.)

Poppelsdorf near Bonn.—The Agricultural Academy at Poppelsdorf is a Royal high class teaching institution connected with the University of Bonn, and matriculated students of the University can take advantage of it under the following

regulations which I transfer from the Director's [Dr. Dünkelberg's] communication to me on the subject:—

"All qualified agriculturists, with the exception of foresters, can pursue their studies here, as also can persons belonging to other professions, and natives of other countries than Prussia, as for instance Russia, America, Austria, Italy, Switzerland, etc. On this point the list of students for the last ten years shews that of late years the attendance of foreigners has increased. This is owing to the fact that, since the summer of 1876, I have added to the agricultural instruction properly so called, a course of agricultural engineering, such as does not exist elsewhere in Europe. This course is at present attended by the Prussian land surveyors, who must pass a State examination in order to be able to practise as professional men or to give evidence legally before a court. These students come here partly in order to obtain a theoretical knowledge of agricultural relations; and partly also to study the special technology connected with the cultivation of the land, which depends upon mechanics and hydraulics, the knowledge of soils and the construction and management of roads, bridges, streams, and drainage, and which they desire to turn to good account for the execution of works of reclamation, road-making, drainage, canal-making and irrigation, so that, both upon large and small properties, they may be able to plan and carry out works of improvement. This is because experience has shown that ordinary engineers, even although they may be clever and well instructed in their special departments, yet make great mistakes when they encroach upon the domain of the agricultural engineer.

* * * * * * *

"Up to last spring, about 200 agricultural engineers had pursued their studies here and had passed their examinations.

* * * * * * *

"Out of the success of this experiment of establishing a course of agricultural engineering has arisen the idea that the plan of instruction in the higher agricultural institutes should not in future be confined to its former scope, but that the wants of the present time must be considered, and new means adopted for the purpose. This however would not have been possible at Poppelsdorf if the Director himself had not for 40 years, in addition to his special agricultural studies, occupied himself with agricultural engineering and until recently in carrying out practical works. This cannot be asserted of any of his agricultural colleagues in Germany, Austria, France or Switzerland."

REPORT ON THE UTILIZATION OF SILT IN ITALY.*

BY

MR. C. H. HUTTON,

Superintending Engineer, Irrigation Works, United Provinces.

PREFACE.

MY deputation to Italy to study the methods there employed for the utilization of silt for the mitigation of malaria and the fertilization of land was due to Sir Edward Buck, K.C.S.I., at one time Secretary to the Indian Government in the Agricultural Department. Since his retirement he has consistently maintained his interest in matters agricultural, and in the year 1905, when attending the Agricultural Conference at Rome, he seized the opportunity of learning and seeing what was being done in Italy in the way of the utilization of silt; and he was subsequently charged by the Indian Government to visit Italy and report on these methods.

The result of his visit has been a most interesting report entitled *The control and utilization of Rivers and Drainages for the fertilization of land and mitigation of malaria*, which gives an admirably clear and comprehensive survey of the history and objects of the works which are being carried out in that country at the present time. It also contains useful suggestions for the application of such methods in India, and it recommends, with that object in view, that one or more Irrigation Engineers should be deputed to Italy for the purpose of studying and reporting on the works which were there being carried out.

Sir Edward Buck accompanied me on my tour, which occupied the latter half of November and the first of December of the past year, and my best thanks are due to him for his assistance with the arrangements for the tour and with the language, of which I have unfortunately only a slight knowledge.

I consider myself fortunate, too, in having visited these works with one who is well acquainted with the needs and conditions of India.

My best thanks are also due to the Italian Government for their kind permission to see the works, among the members of which I may mention Cav. Pasquale Acquaviva, Irrigation Secretary in the Public Works Department, who greatly assisted us and interested himself in our tour.

I should here also like to mention for their kind assistance and arrangement to see the works in their charge—

Signor	Ingenerecapo	at Foggia.
Signor Ubaldo Lenzi	Do.	at Caserta.
Cav. Edvardo Ponti	Do.	at Grosseto.
Cav. Mederico Perilli	Do.	at Ravenna.

together with Assistant Engineers who accompanied us on our tour of inspection.

I am indebted also to the Marquis Rudolfi for his kind permission and assistance in seeing the remarkable and interesting example of "Colmata di Monte," which has been carried out for the last eighty or ninety years on his estate at Mileto.

Lastly, I must not forget to mention Count Pasolino Passolini of Ravenna, who, himself keenly interested in agricultural improvements, accompanied us in our inspection of the works round Ravenna and gave us every possible assistance.

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* Report submitted to Government, 1909.

SECTION I.

(1) In this report I do not propose to go over the ground already covered by Sir Edward Buck in his report—*On the control and utilization of rivers and drainages for the fertilization of land and the mitigation of malaria*—as this gives a very clear account of the past and present history of Bonificazione in a general way together with its object.

I propose, therefore, to deal in detail with the engineering side of the question by describing both the principles on which the works are carried out and the works themselves, as exemplified in those visited by us.

I must also, as the two are so intimately connected, at the same time, treat more fully of the agricultural side. Sir Edward Buck's report must therefore be read and studied as a preliminary to this one.

(2) By the term Bonificazione (the works of which are called bonifiche) is meant, in a general way, the improvement of the land, either from an agricultural or hygienic point of view, or from both together.

Definition of Bonificazione.

The works consist essentially in the hydraulic regulation or systematizing of the tract of country to be improved, by regulating the courses of rivers and torrents, by systematizing their mouths, by erecting embankments to prevent inundation, by raising the level of low-lying lands or by filling up stagnant pools of water with silt derived from the turbid waters of rivers or torrents, by draining these same depressions either by means of cuts having a free outflow, or by means of pumping, by filling up borrow pits along the line roads, railways or canals with silt, wherever possible, or, if not possible, by providing proper facilities for their drainage.

(3) Omitting any mention of what has been done in Italy prior to the unification in 1862, already dealt with in the report mentioned, we may come to the period subsequent to 1862, since when a comprehensive scheme for the gradual Bonificazione of the whole of Italy has been evolved.

The Act of 1900 under which works of Bonificazione are now being carried out.

The Act of 1900, which is the legal basis of all the works now being undertaken, places upon the Government the onus of responsibility for undertaking the Bonificazione of all unhealthy lands, whether private or public; the exercise of the powers, conferred by the Act, being justified by the necessity—

(1) of lessening the difficulties of police supervision,

(2) of removing the causes of malaria.

The first object being explained by the fact that bandits and criminals have been in the habit of taking refuge in the malarial swamps, where the police are afraid to follow them. This is the case, too, in India in the malarious tract known as the Terai.

(4) By the Act of 1900 the works of Bonificazione are divided into two categories:—

(1) In the first are included the more important works of drainage and colmata which have in view a great hygienic or a great agricultural amelioration of the condition of a tract of country, together with, in this latter case and as a result thereof, better hygienic conditions. These works are carried out by State agency, or power to carry them out may be delegated by the State to the province or to the communes.

(2) In the second are included those works in which private interest is (*a*) dominant or (*b*) exclusive. These are carried out by private agency.

(5) Contributions to the expenditure on works of the first category are distributed thus—

The State pays $\frac{6}{10}$, the province and commune $\frac{1}{10}$ each; but this contribution of $\frac{2}{10}$ on the part of the province and communes interested is divided in the ratio of either the area or of the benefits derived, according to whether the area, which has derived advantage is or is not included within the limits of the work of bonificazione.

The proprietors also contribute $\frac{2}{10}$, to be divided among them in the ratio of the effective benefits derived.

(6) In the second category, where the interest is exclusive, the proprietors provide for execution of the works by forming themselves into voluntary associations.

If the interest is dominant the co-existence of a public hygienic or agricultural interest, although limited, imposes on the State or the provinces and communes interested to each provide, respectively, a grant-in-aid of $\frac{6}{10}$ths of the cost, provided that the responsibility of the association may be declared on the initiative of the State or of some of the local authorities.

In other cases the possibility of subsidies from the provinces and communes is not excluded, but these same grants-in-aid are of the nature of advances rather

than actual grants, and of the amounts thus granted reimbursement is in fact admitted after the work is completed, independently of the "plus valenza" (enhanced value), which in every case remains to the advantage of the proprietors, whatever may be the category of the work.

(7) Easy terms of repayment are granted to the association whose quota of the above grant-in-aid may be recovered as an annual rate spread over from 5 to 30 years, according to the contributing powers of the authorities and proprietors interested.

The proportion contributed by the State nevertheless cannot be altered—*e.g.*, in the case of concessions it cannot exceed $\frac{6}{10}$ths of the amount of the projects carried out, with the addition of 12 per cent. for contingencies and unforeseen works.

(8) By whatever agency the work of Bonificazione may be carried out, it is obligatory on the part of the proprietors to maintain them at their own cost.

(9) Every care is taken to harmonize, in the best manner possible, the rights of private individuals with public requirements.

In case disputes arise over the question of expropriation or damage, arbitration is provided for.

Not less care is taken to reconcile the common interests with the rights of individuals.

(10) In cases in which the majority of the common interests equally with the public interests predominates, an association must be formed to carry out works of the second category. The association must acquire the land from the dissentient and indemnify them for it by an annual rate spread over not more than 20 years.

(11) The proprietors are allowed to remain in enjoyment of their farms, with the exception of the buildings, during the execution of the works, and are allowed to remain in possession of their lands after the works have been finished provided they renounce the indemnity, which the association, under the law for the expropriation of land, must otherwise have paid.

(12) The public authorities and proprietors interested may form commissions of vigilance to insure that the work is properly carried out and in such a manner as to secure the object in view.

(13) The second report on Bonificazione presented to the Chamber of Deputies contains some interesting statistics, from which I have taken the following figures.

In works coming under the first category—

	Acres.		Sq. Miles.
(*a*) Area liable to inundation	571,447	or	892
(*b*) Area always swampy, excluding above	1,854,133	or	2,896
(*c*) Area under the torrents of Vesuvius neither liable to inundation nor swampy	564,965	or	885
Total	2,990,445		4,673

Of this total have been—

	Acres.		Sq. Miles.
(*d*) already improved	1,255,085	or	1,961
(*e*) remaining to be improved	1,647,926	or	2,575
(*f*) Balance which comes under neither of the heads above	87,535	or	137
Total	2,990,545		4,673

(14) The expenditure up to 30th June 1900 was Rs. 10,90,96,923 and up to 30th June 1906 was Rs. 13,53,29,235, or an expenditure of Rs. 2,62,32,312 during the 6 years that have elapsed since the Act of 1900 was passed. That is to say, the expenditure has been at the rate of Rs. 43,72,052 per annum.

In addition to this, in the same period 1900-01 to 1905-06, a sum of Rs. 13,93,818 represents the sum contributed by the State to works which came under the second category, and for a few works which are still being carried out under the law of 1882.

(15) There are no figures to show what proportion of the expenditure has been incurred on colmata, nor of the area in which colmata has been either finished or is still in progress, but there can be no doubt that works of drainage and protection from inundation have been and are much more extensive than the works of colmata: for example, at Capua the area under colmata is only $\frac{1}{3}$ of the area under drainage.

I should say that of the total swampy area of 2,897 square miles certainly not more than about $\frac{1}{4}$, or say 700 square miles, or 458,000 acres, have been or are actually under colmata.

These figures include the work done before the unification, such as the Val di Chiana, but do not include the works being carried out under the second category, either by concessions or private individuals.

(16) Among the works mentioned in paragraph 2, as coming under the term "Bonificazioni," there are two methods by which a tract of land wholly or partly marsh can be improved. One of these is drainage by free flow or pumping; the other is by raising the level of the land with silt (colmata).

It was for the purpose of studying this latter method in particular that my recent visit to Italy was undertaken.

Before, however, proceeding to describe the different works which were visited it will, perhaps, be better to set forth the general principles according to which these works are carried out.

Definition of Colmata.

(17) The term "colmata," which is derived from "colmare—" to heap up, means the process of depositing silt on low-lying lands for the purpose of raising them or for the purpose of fertilizing them. The equivalent French word is "colmatage," which is derived from the Italian. For want of any English word which would convey the precise meaning, I intend to use the Italian word "colmata" throughout this report.

(18) The art of colmata is undoubtedly Italian, and one of the first works of Bonificazioni undertaken in Italy was the improvement of the Val di Chiana in the province of Tuscany.

This work, which has consisted in the regulation of the torrents and drainages and also in the raising of the swampy and malarious low lands by means of silt (colmata), was commenced in the middle ages, and has been proceeded with up to the present time. The result has been that it is now one of the most fertile and healthy tracts in the whole of Italy.

(19) It may be stated here that the colmata of swampy lands with high spring levels, wherever possible, is generally considered preferable to drainage, as the results are more complete and satisfactory both from an agricultural and an hygienic point of view.

By agriculturalists especially it is considered "a grave error not to profit by fertile silt whenever it is available."

Preliminary investigation required prior to undertaking any project for Colmata.

(20) The preparation of any project for the application of silt to land must be preceded by a preliminary study of the quantity and nature of the silt at different seasons of the year in the waters of the rivers and torrents which it is proposed to utilize: also, of the mean volumes of silt which it is possible to obtain in a year or in certain seasons of the year. It must also be considered if the silt is suitable for the purpose in view, for silt may be applied to land either solely for the purpose of raising it, in which case as a rule the silt can be applied during any flood or at any stage of the flood, or for the purpose of rendering more fertile land which is already productive, and which does not perhaps suffer from defective drainage. In the former case the silt is applied once for all, but in the latter it may be applied from time to time.

(21) In the case of silt applied for the purpose of fertilization, it will generally have to be put on for shorter periods and at only predetermined states of the flood. Generally the lighter particles of silt in suspension, which predominate in the more superficial *strata* of the water, are those which it is desirable to apply to the land and these are to be found more especially in a rising flood than in a flood at its full height or when falling.

(22) In the case where it is sought to improve the physical or chemical properties of the soil, silt of a clayey nature is required for the correction of specially light or porous lands; but, on the other hand, for lands which are heavy and of low permeability, silt with a large excess of sand is desirable.

(23) The volume and richness of the silt held in suspension naturally varies very much from one locality to another with the geological character of the soil, its cultivation, the velocity of the stream, etc.

(24) In general, the amount of silt is calculated at from 3 to 5 per cent. as a mean, and in the case of the Reno, in the province of Bologna, 7 per cent.

Methods of Colmata.

(25) According to Professor Niccoli, in his "Idraulica Rurale," the raising of low lands with silt may be proceeded with in two ways:—

(1) By diverting the whole volume of the river or torrent into the marsh, which, when it is a shallow depression, only necessitates its being surrounded with an embankment to prevent the water spreading over the adjacent dry lands. In this case the basin so formed must be provided with escapes or overflow weirs of ample width to avoid an excessive raising of the water level, which would endanger the embankment.

The works at Manfredonia (Cervallo and Cancellaro torrent), at Piombino (Cornia torrent), at Ravenna (Lamone torrent), are examples of this system and will be described later.

(2) By taking only such a proportion of the silt-laden waters of a river or of several streams, as will suffice for the purpose, by means of a diversion canal or canals, having either an open head or provided with a regulator fitted with gates.

The works at Grosseto and Capua are examples of this system and will also be described later.

Free and regulated systems of colmata.

(26) The raising of low-lying lands with a deposit of silt have been classified by Professor Niccoli, as either "free" or "regulated."

By the former is meant the partial or total diversion of the silt-laden waters of a river into a depression, the necessary works being limited to obtaining the supply of turbid water and at the most to directing and providing for the discharge of the water introduced into the depression. In such cases the stream takes the line of least resistance along the bottom of the valley and quickly begins to put itself into a state of equilibrium, by forming with its sediment both bed and banks, so that, in most cases this channel eventually divides the swamp into two parts which are most difficult and tedious to silt up. The constitution and the gradual successive raising of the channel carries with it a twofold result—

(1) a large part of the silt is carried across the marsh in this new channel without being deposited;

(2) the bed of the river, up-stream of the swamp, begins to rise, often with the result that the hydraulic condition of the higher-lying lands deteriorates.

In conclusion, "free" as opposed to "regulated" colmata is irregular in its effect, is very slow in action and nearly always causes more or less damage to the conterminous lands, its only advantage being its low cost.

Law of the settlement of silt held in suspension.

(27) Professor Niccoli in this same treatise lays down the following 4 laws with reference to the settlement of silt held in suspension :—

1. The precipitation of the heavy and coarse particles of silt (sandy) is far more rapid in each stratum than that of the light and fine (clayey); and probably the total depth of the turbid water has a somewhat less influence in the case of the former than in that of the latter on the duration of time necessary for complete precipitation.
2. By opportunely regulating the height of the stratum and the duration of the decantation, the sandy and argillaceous particles can be deposited in a determined proportion.
3. The clearing of the upper stratum is altogether more rapid than that of the lower stratum especially when the turbid waters are rich in fine and light particles.
4. It is convenient in order to shorten the time of precipitation, especially of clayey particles, to limit the depth of turbid water in the basin and possibly to draw off the upper stratum (in which the precipitation is quicker) while still hardly clear, in order to be able to admit a fresh supply of turbid water.

Regulated colmata.

(28) In treating of regulated colmata, by which is meant that the turbid waters admitted to the inside of the basin are diverted by means of secondary banks and channels and assisted by means of over-flow weirs in order to induce the deposition of silt in a more regular and more rapid manner, there are five methods which can be followed to secure the precipitation of the particles of silt in suspension, and the choice of one or the other has a very great influence on the duration of the operation. A layer of turbid water of height can be admitted into the basin, and then one can proceed with one or other of the following methods :—

(1) By allowing the clear water after precipitation to be dissipated by evaporation or infiltration (if the bottom is not impermeable), after which a fresh supply of turbid water is introduced. This method is generally condemned, as it naturally takes a very long time. The action is intermittent, but the sedimentation is complete.

(2) By allowing the water to remain in the basin until it is completely cleared, whereupon it is escaped and a fresh supply of turbid water is admitted. A good deal of time is lost by this method, too, in emptying and filling the basins and, in the meantime, it is not possible to utilize the turbid water in the river. The action and the results are the same as in No. 1.

(3) By discharging the water before it is completely clear. A greater quantity of the turbid water will thus be used, and the precipitation will be more rapid and the heavier particles will predominate over the lighter. The action is intermittent and the sedimentation partial or incomplete.

(4) By decanting or running-off the upper stratum of water gradually and continuously, as it becomes completely clear, and at the same time admitting a fresh supply of turbid water. The action is continuous and the sedimentation is complete.

(5) Under the same conditions as in the preceding case, the turbid waters are escaped before they are completely clear, and at the same time a fresh supply is admitted, the action being continuous and the sedimentation partial.

(6) Methods 3 and 5 will result in a sedimentary deposit, in which the argillaceous particles are more or less absent.

(7) Methods 4 and 5 will take the shortest time, because, in the first place, no time is lost in filling or emptying the basin ; secondly, because the precipitation in the upper stratum is, other conditions being equal, more rapid ; and thirdly, because in this way the greatest volume of the turbid water of any flood can be made use of. Either the second or fourth methods must be followed where it is forbidden to discharge turbid water into the drains for fear of silting them up.

(29) Generally, when the amount of raising is considerable, a mete or more, it is desirable that the first deposit should constitute an open stratum, and, for this purpose, a deposit of the heavier sandy particles is required to secure which methods 3 and 5 should be followed. On the other hand, the upper stratum of 50 or 60 centimeters (1·5 to 2·0 feet), at least, should consist of a just proportion of clayey and sandy particles, rich in matter adapted to the nutrition of plants. As has already been mentioned, these richer particles are, as a rule, the lighter and smaller, and are therefore the last to be deposited. To secure this either method 2 or 4 should be followed.

Other methods of regulating colmata.

(30) Colmata can also be carried out, in addition to the methods enumerated in para. 28, in either of the following ways :—

(*a*) Turbid water may be admitted into a large number of little trenches, excavated in low-lying ground, when the silt, owing to the slackening of the velocity, will be deposited. This deposit of silt is then dug out and used to raise the adjacent land, and the process is repeated until a sufficient height is obtained to render the land fit for cultivation.

(*b*) The lands may lie along the course of an embanked river at a level but little above or below the ordinary water surface level. In such cases a supply of turbid water can easily be obtained for the purpose of either raising or fertilizing the land by constructing small outlets in its banks.

(31) Having fixed on the site of the basin (baccino or cassa di colmata) the area is surrounded with a strong bank to contain, if possible, the whole of the waters of a flood, or as much as the diversion canal is calculated to give during the occurrence of a flood. Arrangements must be made for the free drainage of the lands immediately outside the basin, and this can be done by means of percolation drains leading into a main drain, which it is generally found convenient to open along the outside of the marginal embankments.

It is usually best to divide the basin into compartments by means of secondary embankments. which can be filled one after the other, according to the volume of flood water coming into the basin. By this plan the distribution of the turbid water can be regulated and the precipitation of the silt, the discharge of the clear water and the re-charge with turbid water will be expedited.

Drains.

(32) The internal network of drains which will be required when the work is completed must be foreseen, and the colmata must be so regulated as to give a suitable slope to the raised surface.

(33) The following formula (variously applied in different places) gives the level H in meters to which the surface of the land must be raised above the mean level of the recipient of its drainage :—

H in metres = $0{\cdot}15\,(d \pm 10\,a) \times 2{\cdot}0$, where (d) is the distance of the land expressed in kilometres and measured along the drain which leads to the recipient, and (a) is the height of the land in metres with reference to the surface of the water at the outfall of the drain, negative if above it and positive if below it.

(34) The frank of 2·0 metres (6·76 feet) in the above formula is the level the land at the outfall must have above the ordinary water-level.

It is fixed on the consideration that it will be eventually reduced by settlement and consolidation by about one-third or to 1·34 metres (4·40 feet).

On the opening up of the percolation and agricultural drains it is considered desirable, for agricultural and hygienic reasons, that the subsoil water should be not less than 0·80 to 1·0 metres (2·5—3·25 feet) below the surface of the ground.

(35) With the object of regulating the alluvial deposit various measures are adopted, such as extending the principal supply canal through the fan of silt deposit from time to time as required, opening up secondary channels to direct a concentrated volume of turbid water into the lowest places, or wherever there may be need of it, dividing off with banks from the main basin such areas as have been raised to the desired height.

Regulation of the colmata.

The deposit of silt can be promoted by little cross-banks, surrounding tracts nearly finished, and by opening up drains to provide earth for such banks. These drains should run in the direction of those which will be required when the work is finished.

(36) In order to be able to direct and regulate the operations intelligently a plan showing the actual and the required heights at intervals of 250 metres should be prepared, the actual heights being taken every summer when the basin is dry.

(37) As a rule it will be better to raise the higher land inside the basin first, in order that such lands may be quickly brought under cultivation.

When, however, there is but little slope in the diversion canal, colmata must be commenced in the more distant and depressed parts, otherwise the cone of silt, which is rapidly formed at the mouth of the canal, will cause the canal itself to silt up, with the result that the supply will be diminished. An excessive restriction of the basin may lead to the same bad results.

(38) Too large a basin on the other hand will render the regulation of the colmata more difficult, and, as already mentioned, it will be well to sub-divide it into compartments with banks somewhat lower than the marginal embankment.

It has been a common defect in the past to strive to inclose too much land. The objections to this are :—

(*a*) Greater capital expenditure in land, earthwork and masonry works, on account of the greater volume of water required.

(*b*) Higher maintenance charges in consequence of the greater difficulty and expenses in guiding and regulating a larger volume of water.

(39) The diversion canal should have its bed at its entrance into the basin but little below the level to which the ground at that point has to be raised.

Diversion canal.

(40) The works for the discharge of the clear water from the basin are overflow weirs and discharge sluices in the marginal embankment, and are of a temporary or permanent nature according to the length of time the operations are likely to take.

Discharge sluices and weirs.

(41) The following are the causes which have led to too favourable forecasts as to the time necessary for the complete colmata of a tract of land :—

Causes which have led to the falsification of forecasts.

(*a*) Over-estimation of the amount of silt held in suspension.

(*b*) Neglect to make any allowance for settlement not only of the new silt deposit, but also of the underlying soil.

(*c*) Neglect to make any allowance for silt carried away by the water discharged from the basin.

(*d*) Neglect to make any allowance for lands raised accidentally higher than calculated for.

SECTION II.

Description of Bonificazioni Works Visited.

Bonificazione at Ostia.

(1) The drainage works in the neighbourhood of Ostia, the ancient port of Rome, at the mouth of the Tiber, afford an interesting example of the improvement (bonifica per prosciugamento meccanica) of a low-lying and swampy tract of country by means of free-flow drainage and also by pumping.

Drainage works at Ostia.

(2) This tract is divided into three portions by the Tiber and the navigable canal from the sea to the Tiber : that to the south is called the " bonifica " of Ostia ; that in the centre the " bonifica " of Isola Sacra; and that to the north the " bonifica " of Maccarese.

The area of each of these tracts is as follows :—

Ostia	4,693 acres.
Isola Sacra	2,346 ,,
Maccarese	10,621 ,,

(3) The works in connection with the former only were visited by us, but are typical of the others also.

The lowest lying land is 1·1 metres (3·6 ft.) below the sea-level and the three depressions are separated from the sea by sand dunes. There are three series of drains which meet at the pumping station.

One of the cardinal rules in connection with drainage works in Italy is that the high waters must be kept separate from the low, and the turbid waters from the clear, more especially where pumping has to be resorted to.

These drains are known as the high, middle and low-level: the first intercepts all the drainage from the uplands and carries it into the basin below the pumping station, where it flows freely away to the sea.

(4) As a general rule it is considered necessary that, during the rainy months, the level of the sub-soil water should be at least 0·60 metres (2·0 ft.) below the surface, in the case of pasturage lands or natural meadows; and from 0·8 to 1·0 metres (2·6 to 3·3 ft.) if cultivated or planted out with trees. These rules apply to light soils only and, if they happen to be heavy and irrigated, the above amounts must be increased by 0·10 to 0·20 metres (0·3 to 0·6 ft.). This frank applies not only to the lands along the drain, but to the more distant tracts which must be put in the same condition by means of agricultural ditches (fossi agricoli).

(5) Plate No. 1 shows the system of drains in this case.

(6) Generally the percolation drains (collettori) are at 300, 500 or even 1,000 metres (984, 1,640 or 3,280 ft.) apart, while the agricultural ditches are opened at $\frac{1}{10}$th of these distances so as to divide the land into equal squares. It is found, however, that the land settles down and consolidates when it is dried by drainage and an allowance must be made for this in any drainage project to the extent 0·50 metres (1·6 ft.) or more in muddy bottoms; 0·30—0·20 metres (1·0 to 0·6 ft.) in moderately light soil and even less in clayey soils, while sandy soils settle hardly at all.

(7) As a general rule the slopes of the intercepting drains should not be less than 1·0 to 0·50 per thousand according to whether the drainage waters intercepted are more or less turbid; the main drains (collettori) can have a slope of 0·50 per thousand as a minimum and the percolation drains (primary) a minimum of 0·10 per thousand and the secondary and tertiary a minimum of 0·15 to 0·20 per thousand. In the collecting drain the minimum slope should depend on the velocity of the water when in flood; this should not be less than 0·30 metres (1 ft.) per second to prevent the excessive growth of weeds.

Maximum slopes for drains.

(8) The maximum limit of slopes in percolation drains is from 1·5 to 3·50 per thousand, and in collecting drains 0·5 to 2·00 per thousand, with the reservation that light soils must not be subjected to a greater velocity than 1·0 metres (3·3 ft.) per second and strong soils to a velocity greater than 1·5 metres (5·0 ft.) per second. In the case, however, of drainage by pumping flatter slopes are given in order to carry off as much water as possible by free flow, and, although such slopes will necessitate the drain being cleared 3 or 4 times a year, the saving in the cost of the wear and tear of pumping will more than counterbalance the cost of clearing the drains.

(9) In cases where a considerable amount of silt is brought down into the contour intercepting drains it may be necessary to give a greater slope to prevent their becoming choked. In such cases two drains—a high and a middle level—may be substituted for the one at the high level.

Slopes of drains when pumping is resorted to.

(10) In this latter case, *viz.*, of pumping, the slopes of the collecting drain can be as low as 0·03 per thousand and of percolation drains 0·10 to 0·05 per thousand and intercepting drains 0·10 or even less.

In both collecting and percolation drains the mean velocity in flood time, especially when pumping is resorted to, should be from 0·60 to 0·40 metres (2·0 to 1·3 ft.) or still better 0·70 to 0·60 metres (2·3 to 2·0 ft.) per second.

(11) Considering then a longitudinal section of the drain the flood-level line should be at about ground-level, and a line lower than this by 1·20 to 1·50 metres (3·9—4·9 ft.), with regard to what has been said previously as to the demands of agriculture, will represent the ordinary surface of the water in the rainy months and the bottom of the drain will be 0·20 to 0·40 metres (0·6 to 1·3 ft.) lower still.

(12) Situated above and below the pumping station respectively, are the collecting basin (vasca di arrivo) and the discharge basin (vasca di scarico); generally rectangular in form and of a width and length double or treble that of the collecting or discharge canal in order that the effect of the draw in the first case or of the back-water in the second may be as small as possible. The bottom of the collecting basin is put 0·50 metres (1·6 feet) below the bed of the collecting drain and near the pumps it is 1·0 to 1·5 metres (3·3 to 4·9 feet) deep.

(13) It is considered sufficient, both in regard to agriculture and hygiene, if the pumps maintain the ordinary water during the rainy months at its normal height, which means that the pumps must raise c.m. 0·06 per square kilometre (5·6 c. ft. per

square mile) and this is the factor adopted generally for the Agro Romano, *i.e.*, the country round Rome.

Ostia pumping station.

(14) In the Ostia pumping station there are two turbine lifts, one for the middle level and one for the low level. The following table gives particulars as to lift and discharge:—

MIDDLE LEVEL TURBINE.

Maximum lift 1·7 metres (5·6 feet) discharge 4·500 c. metres per hour (44·5 cusecs).

Average lift 1·0 metres (3·3 feet) discharge 7·500 c. metres per hour (74·2 cusecs).

LOW LEVEL TURBINE.

Maximum lift 4·0 metres (13·1 feet).

Mean lift 1·8 metres (5·9 feet).

Low lift 1·3 metres (4·2 feet) discharge 3·600 c. metres per hour (35·6 cusecs).

The discharge of the high level drain was based on a rainfall of 36 millimetres (1·44 inches) in 24 hours, and that of the middle and low level drains of 16 millimetres (·62 inches) in the same time.

It was calculated that the number of days for which the pumps would run continuously would be 43 to 46.

The horse-power required in the case of Ostia tract is 1·64 per 100 hectares (0·66 H.-P. per 100 acres per 1 metre (3·28 feet) lift, and, in the case of Isola Sacra and Maccarese 2·81 and 1·52 respectively (1·14 and 0·60 H.-P. per 100 acres).

(15) The statement No. 1 appended shows that the average amount of water annually pumped off this area of 4,693 acres varied from 77·2 per cent. of the rainfall, 1·03 metres or 40·55 inches, to 51·0 per cent. of the rainfall, 0·787 metres or 30·98 inches, and was on the average for the 9 years 1897 to 1905, 62½ per cent.; the average rainfall in that period being 0·886 metres (34·88 inches); the amount of water raised, therefore, varied from 0·23 to 0·62 litres per hectare (2·1 to 1·1 cubic feet per square mile) and was a mean of 0·67 litres per hectare (1·5 of cubic feet per square mile). These results, it must be noted, are spread over the whole year.

Drainage factor.

(16) As a general rule the amount to be pumped is based on an off-flow of 1·20 to 1·50 litre per hectare, 10·9—13·6 cubic feet per square mile, varying with the nature of the soil.

For natural drainage in the basin of the Po, from 0·8 to 1·00 litres per hectare (7·2 to 9·0 cubic feet per square mile) is allowed and in the Maremma 1·20 litres per hectare (10·9 cubic feet per square mile). The sections of the collecting drain, to be on the safe side, are calculated to carry 1·5 to 1·20 litres per hectare (13·6 to 10·9 cubic feet per square mile) according to the nature of the soil.

The land in the low levels, although for the most part cultivated, looks poor and sodden in spite of the drainage, and it is not easy to understand why the waters of the Tiber, which have a very high degree of turbidity, have not been utilised to raise the land.

Value of the land before and after improvement.

(17) The income, before the drainage works were carried out, was derived from the sale of the fishing rights and amounted to Rs. 3,600 per annum on an area of 400 to 500 hectares, 988 to 1,235 acres, or Rs. 25 per acre. It now amounts to Rs. 68 per acre, or more than double.

The present selling value of the land was stated to be as follows:—

Land fit for wheat	...	...	360 rupees per acre.
Ditto pasturage	...	...	216 ditto.
Ditto woods and coppices	...	...	120 ditto.

(18) The appended statement No. II shows the cost of these drainage works per hectare.

Table I showing the total amount of water raised and water due to rainfall over the whole area of 1,900 *hectares.*

Year.	Water raised c. metres.	Rainfall in millemetres.	Water due to rainfall in cubic metres.
1897	9,596,400	859·7	16,315,300
1898	8,764,800	768·9	14,590,100
1899	14,057,275	1107·2	21,036,800
1900	13,477,200	1102·5	20,947,500
1901	11,276,925	804·3	15,281,700
1902	7,629,600	787·3	14,958,700
1903	11,267,025	1031·1	14,590,900
1904	8,056,950	768·2	14,595,800
1905	7,457,175	750·7	14,263,300
Total	91,573,350	7979·9	146,580,100
Mean	10,174,818	886·6	16,286,677

Table II showing the cost of the Ostia Drainage Works in Lira.

	Ostia per		Isola Sacra per		Maccarese per	
	2 K. M. 19.	Hectare.	2 K. M. 8·5.	Hectare.	2 K. M. 43.	Hectare.
Cost of construction ...	1,270,000	668	267,000	281	1,845,000	429
Annual cost of working the pumps and sinking fund capitalized at 5 per cent.	640,000	337	165,976	175	1,169,600	272
Annual cost of maintenance of all the works, less the preceding, capitalized at 5 per cent.	19,930	11	280,000	295	408,000	95
Total	1,828,830	1016	712,976	751	3,423,600	78

The ultimate cost of drainage of the Ostia tract will be Lira 1868, and of the Maccarese tract Lira 1706 per hectare.

Bonificazioni at Foggia.

Description of the tract of country.

(1) Between latitude 41° 24′ and 40° 53′ of latitude and 3° 29′ and 2° 57′ of longitude (with respect to Rome) there is tract of country on the shores of the Adriatic, whose limits are the mouths of the rivers Ofanto and Fortore, and in the middle of which rises the promontory of Gargano.

This promontory induces the littoral current to follow curved lines at some little distance from the two deep bays which exist on either side; and thus, little by little, the sand, which was deposited with slackening of the force of the current, has formed dunes which, together with the extension of the deltas at the mouths of the Ofanto and Carafelle, have inclosed these bays. In this way, deep salt lakes were formed which in the course of centuries underwent great transformations. To the north of this promontory the river Fortore and to the south, the rivers Candelaro, Cervaro, Carafelle and the Ofanto slowly deposited their silt in these bays which had been shut off from the sea.

In ancient days, before the Roman epoch, and also for some years after, the country was both populous and healthy, but the horrors of the Punic War first, and then those of the fratricidal strife between Cæsar and Pompey, brought desolation and destruction everywhere.

(2) In addition to the above, the salt lakes, with the increasing deposits of silt, became changed into marshes and the river beds rose, with the result that when in flood they spread all over the surrounding country, which in consequence gradually became more and more unhealthy and malarious.

(3) The rivers Cervaro and Candelaro are of a torrential character. Rising in the Appenines they unite in the lower part of their course, where they collect the drainage of the surrounding country and form a great swampy region 26,676 acres in extent. Within this area are the Contessa lake, 7,889 acres; the Pantano Verzentino, 1,383 acres; the Colentano, the Salso lake, 1,156 acres; and the Sipontine swamp, 889 acres; but the lands to be rendered healthy in the valleys of the Candelaro and Cervaro measure in all about 69,481 acres or 108·5 square miles.

(4) In these low-lying lands the water remains stagnant on account of the natural depression of the surface of the soil and the difficulty of the drainage, which the sea resists with the continuous formation of bars and dunes; and, besides with-

drawing from agriculture and pasturage thousands of acres of land, generates an intense form of malaria the fatal effects of which cause the surrounding country to remain deserted by the inhabitants of Foggia, Manfredonia and other towns with a total population of 160,170.

(5) From 1807 onwards many attempts were made, both by the proprietors and also by the Government of the time, to better the agricultural and hygienic conditions of the country-side; but they were for the most part unsuccessful, either through being badly executed or badly maintained, and so this unhealthy region remained uncultivated and uninhabited.

It was not until the Act of 1900 was passed, however, that any comprehensive project for dealing with this tract of country was carried out.

Works of improvement.

(6) Among the various projects which have been carried out are :—*vide* Plate No. 2.

(*a*) The confining within its bed of the lower course of the Cervaro torrent for a length of 3 miles and the construction of the first silt basin, 1,205 acres in extent, at an estimated cost of Rs. 1,91,090, to be followed by the construction of a second basin of 1,119 acres at a cost of Rs. 63,600.

(*b*) The drainage of Lago Contessa and the embankment of the Fosso Farano at a cost of Rs. 4,72,374.

(*c*) The confining within its bed of the lower course of the torrent Candelaro for a length of 4 miles from the Foggia Manfredonia road to the first silt basin of 1,161 acres, at a cost of Rs. 2,29,800.

It is also proposed to embank the upper portion of the Candelaro and its affluents in order to prevent their flood waters spilling over the surrounding country.

(7) As soon as the first series of basins on these two rivers have been silted up, fresh basins will be constructed until the low-lying lands up to the sea have not only been sufficiently raised, but given a slope sufficient for the proper surface drainage of the land. The total estimated cost is Rs. 14,96,105 and it is expected the work will be finished in 25 years. This amount also includes the cost of the maintenance of the pumping plant, etc., of the Sipontine marsh which began to work in 1899, the results of which have been not only most favourable to the health of the neighbouring city of Manfredonia, but have also made possible the cultivation of the land.

(8) The extent of land submerged in the valleys of the Cervaro and Candelaro is 26,676 acres. There are in addition 42,805 acres of swamps and marshes, making a total of 69,481 acres or 108 square miles, of which 3,250 acres have already been improved, leaving 66,230 acres to be improved.

(9) The total cost up to the end of the year 1906 has been Rs. 12,16,698.

(10) The works visited in connection with this Bonifica were those of the Cervaro torrent which has a flood discharge of 7,000 cusecs. The whole volume of the torrent is diverted into the first basin, which is surrounded with a marginal bank of this section—

The banks are raised 0·8 metres (2·6 feet) higher than the level fixed for raising the land with silt. This level is arrived at in this way : a height of 1 metre (3·3 feet) above sea-level is allowed at the sea, *plus* 0·25 per thousand for the drainage of the surface ; thus a point 10 kilometres from the sea would be raised $1+10+2\cdot5=3\cdot5$ metres (11·5 feet). The average amount of raising to be done in this case is about 4·5 feet. The average annual amount of deposit over the whole area of the basin is about 0·8 feet. The cost of making the bank is Rs. 20 per thousand c. ft., a labourer getting Re. 1-8 per day.

This basin has been in operation since 1900 and the silting is now practically completed and a second basin is under construction.

The unreclaimed land is very swampy. This is due not only to springs from the higher ground, but also to the fact that at high tide the sea floods the lowest levels.

Rupees 20 per acre is paid for this land when it is taken up for the purpose of these improvement works ; it is poor land, only fit for grazing.

The silt deposited seemed to be particularly good, as also the strip of land along the course of an old river channel now completely silted up.

(11) The country from Foggia to the sea is singularly devoid of trees, but the soil appears to be very good and would, no doubt, be more productive if artificial means of irrigation were possible ; but the summer months are very dry, and practically only one crop is grown, *viz.*, wheat sown in October. Large flocks of sheep come down in the winter to graze on the marshy lands and in the summer are driven up to pastures on the hills.

(12) The methods of working the silt basins is simple. The inlet channel is continually being advanced as the silt is deposited, and subsidiary channels are also dug for the diversion of the turbid waters to the desired spots.

Method of working the silting basins.

Escape.

(13) The escape is made at the lowest place. Plate No. 3 will show the kind of work.

The sill is at first 0·5 metres (1·6 feet) above the ground, and when the silt reaches this level it is raised with fascines another 0·5 metres : and so on until the required height of silting has been reached.

(14) In addition to the outlet weir, an overflow weir is provided at the highest part, to prevent the banks being breached in the case of extraordinary floods.

Overflow weir.

(15) As has been already stated above, a small tract of low-lying land known as the Sipontine marsh, 889 acres, has been much improved by drainage. The water from higher grounds are intercepted by a high level drain along which the water flows away to the sea. The water from the lower levels has to be raised by means of a turbine pump. The lift is small above 0·25 metres (0·8 feet) on the average and 1·25 metres (4·1 feet) as a maximum.

Drainage by pumping.

(16) The cost of pumping, clearing drains and general maintenance amounts to Rs. 10,800 per annum, or nearly Rs. 12 per acre.

Cost of pumping.

The cost of the works, including drains, pumping house, machinery, etc., was Rs. 2,10,000. Briquette coal costs Rs. 24 per ton here.

Bonificazioni at Capua.

(1) The extensive alluvial plain which lies between the promontory of Miseno and Carinola constitutes the lower basin of the Volturno. *Vide* Plate No. 4.

The Volturno river has scoured a channel for itself through this plain in which, towards the sea, there are extensive marshes with dense vegetation.

(2) The backward state of cultivation in this tract before 1839 was due to several causes—first, to the formation of several lines of dunes which caused the waters between them to stagnate and also obstructed the drainage of the higher-lying land ; secondly, to the inundations of the Volturno. Both these causes gave rise to a severe form of malaria from the marshes which were formed. In consequence it was impossible for the cultivators to live on the land during the malarial season and cultivation was thereby greatly hindered. Thirdly, to the difficulty of communication across a tract of clay soil owing to the absence of road.

The works of improvement were commenced in 1839. An extensive network of drains, aggregating 227 miles in length, has been made to drain the higher lands and the turbid waters of the Volturno river and of the torrents Savone, Rivo Rota and Rivo S. Paola have been diverted to silt up the swamps and marshes ; a number of agricultural roads have been constructed also.

Great improvement in the condition of this tract has been the result of these works which are still in progress. Malaria has partly disappeared and inundations which were formerly so frequent have been prevented by embankments.

(3) The maximum flood discharge of the Volturno is 71,000 cusecs, the mean annual rainfall at Caserta is 29·13 inches and the maximum 35·43 inches. The area of the drainage basin is 2,072 square miles of which 96 per cent. is hilly. Its bed slope in the plains portion is about 1·30 per thousand.

Volturno River.

(4) The amount of silt carried in suspension by the waters of the Volturno is very great : it is about $\frac{1}{100}$ as a mean, or 1 per cent.

Amount of silt in the water of the Volturno.

(5) The season of floods lasts from October to April, and it is only during this period that silting operations are carried on.

For the remainder of the year the canals are closed by earthen bunds thrown across their heads to stop all leakage, since some of the land under colmata is then cultivated. For hygienic reasons, too, it is most essential that all the silting basins should be drained off as far as possible during the summer months, as it is in these months that the mosquitoes breed and that there is, in consequence, greater fear of malaria.

(6) The particular attention of the Engineers, here and elsewhere engaged in similar work, has been drawn by the Government to the necessity of draining off all water that would otherwise stagnate, and of clearing all jungle off the slopes of the canals to restrict, as far as possible, the breeding-grounds of these mosquitoes.

(7) During the flood season there are about 27 floods lasting on the average about 3 days each.

(8) The sea has in the course of time thrown up a series of sand dunes along the coast, the section of the country being something like that represented in the marginal sketch. The hollows between the sand dunes are below sea-level and are very swampy.

Reclamation of sand dunes.

This tract was under reclamation when we saw it. The tops of the sand dunes are first levelled off into the hollows; and then, as the dunes are composed almost entirely of light sand, the turbid waters of the Volturno are directed over the land for one season and allowed to deposit their silt: in this way a top stratum of good soil is formed which is sufficient to turn these dunes into good agricultural lands.

(9) The total area of the alluvial plain is 308,810 acres, or 474·7 square miles, of which 222,300 acres have been dried by means of drainage: 54,345 acres have been raised by means of silt from the waters of the river Volturno and the torrents Savone, Rivo di Lanzi, Rivo Rota, Fossoriccio and Rivo S. Paola; and there are another 19,760 acres undergoing silting operations.

Silting operations (Colmata) began in 1838. The expenditure up to the end of 1900 has been Rs. 1,38,00,000, of which 7·2 millions of rupees were provided by Government and 6·6 millions of rupees by the proprietors from a tax on the lands. Another six millions have been provided for the completion of the work, so that the total cost will be about 19·8 millions of rupees. The cost per acre will therefore be $\frac{198,00,000}{3,03,810}$ = 161 Rs. The cost of the raising of the land by means of silt is no doubt very much greater, but separate figures for this are not available.

(10) The land which has already been raised by silt is very fertile and, it is said, will not require any manure for the next 10 years. The land after improvement is laid down as pasture for a year or two before being brought under cultivation. The principal crops are wheat and beans, sown in October and reaped in June and July, followed by maize sown either in June and reaped in September or sown in August and reaped in November.

(11) Silting operations are being carried on by means of three diversion canals, *vide* Plate No. 5.

The first, however, on the left bank some kilometres above Cancello, is still under construction. The canal bed at its head will be 0·5 metres (1·6 feet) below low-water in the river and will have a slope of 0·36 per thousand: 0·35 per thousand is considered to be the minimum slope to be given to such diversion canals to prevent the silting of their channels.

The maximum discharge of this canal will be 8,100 cusecs. Ordinary floods in the Volturno reach 15 feet above the low-water level and an extraordinary flood as much as 23 feet. The canal head or regulator, very similar to such works in India, consists of 7 spans of 4 metres (13·1 feet) each, with piers 1·5 metres (4·9 feet) thick, with a total width between the abutments of 37 metres (121·3 feet), although the bed width is only 12 metres (39·3 feet).

The down-stream slopes are protected for some 100 to 150 feet with masonry in lime, but no protection is considered necessary for the bed.

Besides this head there are several bridges for country roads, and two or three syphons for cross-drainage.

The head is set back from the river about 500 feet.

(12) The second canal on the right is below Cancello. It has a bed width of 15 metres (49·2 feet), a maximum depth of 4·5 metres (14·7 feet) and a mean depth of 2·5 metres (8·2 feet). The maximum discharge is 5,000 cusecs; at a distance of about 2 miles below the head this canal bifurcates.

The head or regulator is of a very ordinary type, and the gates are raised by means of rack and pinion gearing.

(13) The third canal is taken from the left bank of the Volturno. It has a skew head or regulator. The gates are here worked with screw gearing which, though slower in operation than the rack and pinion gearing, enables the gates to be got down more readily in the event of a high flood. These canals had no protection to the bed below the head, but showed no signs of scour. Neither of the two older canals showed any signs either of scour or of silt deposit, and were evidently well designed to carry forward the silt into the basins.

Third diversion canal.

(14) The depth of silt deposit which was measured by me in two places averaged 4·2 feet per 3 years, or 1·4 feet per annum.

(15) The size of the basins in operation ran up to 500 to 600 acres, but their limits are chiefly fixed by the boundaries of the different properties.

The marginal banks are kept 1 metre above water-level.

The inlet channel is being continually advanced through the fan of silt deposit. Low banks are thrown up in succession about 1,600 ft. apart, and to the height to which it has been decided to ultimately raise the land. These are for the purpose of retarding the flow of water towards the escape opening, *vide* marginal sketch.

The level to which any point has to be raised is arrived at thus :—1·40 metres (4·6 feet) at the sea above sea-level, *plus* 0·1 per thousand according to its distance from the sea.

Escape.

(16) The escape for the clear water into the main drain is, as a rule, situated at the lowest place and is an open breach in the bank. If there is any danger of turbid water escaping into the drain it is bushed up with brushwood. It is considered very important not to allow such water to escape into the drains, as they might become silted up.

Drains.

(17) These drains are given a minimum slope of 0·20 per thousand which, with clear water running in them, is considered sufficient. As tracts of land are raised to the fixed height they are cut off from the basin by means of banks and provided with drains. The silt deposit is wonderfully uniform, and no final levelling by hand ever seems to be required.

The cost of earthwork in canal embankment is Rs. 10·4 per thousand c. ft., and of the excavation of the new diversion canal Rs. 11·7 per thousand c. ft.

Bonificazioni at Grosseto.

The Maremma Toscana.

(1) Before proceeding to describe the works of improvement at Grosseto and Piombini it will be both interesting and instructive to give a short description of the history and nature of the tract of country called the Maremma Toscana in order that the scope of the works there, as well as that of several other similar works in the locality (which however were not visited), may be the better understood.

(2) The name Tuscan Maremma was applied at the beginning of the century to the littoral plain (the drainage of which is especially defective) between Livorno and the torrent Chiarone, forming the boundary between the provinces of Rome and Tuscany. As the country round Livorno became redeemed from malaria, so the northern limit of the Maremma came south to S. Vincenzo ; from this latter place to the Chiarone torrent there is a littoral zone, 93 miles in length, which is separated from the sea by sand hills and dunes, and in which marshes, stagnant ponds and swamps succeeded each other in vast depressions. If one joins the two extremities with the Castel of Paganico in Grossetano on the right of the Ombrone, one has a triangular area of about 610,000 acres, and this includes that part of the country which, on account of its unhealthiness, is still called the Tuscan Maremma.

(3) The principal swamps in this tract are those of Piombini, Scarlino, Castiglione di Pescaia, Alberese, Talamone, Orbetello, Burano.

Past history of the Maremma.

(4) In the time of the Etruscans the country appears to have been salubrious, and it is thought that it was after 300 A.D. that a littoral barrier commenced to form which, in the course of time, closed the Gulf of Castiglione and transformed it into a lake.

The creation of these vast swamps and marshes has been due not only to the filling up of the bays of the sea with the silt brought down by the torrents, but also to slow undulating movements along the Tirrhenian coast which has raised some parts and depressed others. The swamp of Castiglione in the 14th century barely communicated with the sea, and at the end of the middle ages it had become pestilent and malarious. In the 16th and 17th centuries communication with the sea was completely cut off and the gulf became gradually transformed into a swamp.

(5) The gradually increasing unhealthiness of the country, due to the extensions of swampy lands, added to the invasions of the barbarians, the scourge of pirates and the fratricidal war between the Republic and the Signoria, led to the desolation and abandonment of the Maremma ; and it was only when the Medici rule was established that any attempt was made to remedy the deplorable state of affairs.

(6) It was not, however, until the house of Lorraine succeeded that of the Medici that a new era opened up, and henceforward the problem of improvement of this territory was kept in view. In 1765 the Grand Duke Leopold I called in the mathematician Ximenes to the direction of the hydraulic works, but little benefit was obtained from the works he carried out.

(7) In 1826 Leopold II, who had succeeded to the Grand Duchy of Tuscany, personally interested himself in the work of improvement and showed himself desirous of following in the footsteps of his grandfather. He first called in Professor Giorgini, who considered that the chief cause of malaria was the mixing of the salt water with the sweet and proposed works to prevent this.

(8) Fortunately, however, before the works were much advanced, Fossombroni of Arezzo, who had become well-known for his marvellous work in the improvement of Val di Chiana, appeared on the scene.

This latter, while showing his approval of the separation of the sweet water from the salt, counselled the adoption of the radical remedy of " Colmata," which had been resorted to in the case of the Val di Chiana. He proposed to utilize the

silt in the waters of the Ombrone, the Bruna and the Sovata, and he calculated that eight years would be sufficient to raise to the same level the whole of the Maremma of Grosseto, including the swamp of Castiglione.

Alessandro Manetti, however, who succeeded to the execution of the works, considered the period allowed too short and increased it to 22 years.

(9) In 1829 the first diversion canal was begun from the Ombrone at Buccace, with a bed width of 14 metres (46 feet) and discharge of 1,250 cusecs, and a weir 3 metres (9·8 feet) high above the bed of the river was constructed below its off-take. The rivers Bruna and Sovata were also diverted into the swamp, but in 1854, as they had become harmful to the plains which had been raised, they were embanked and carried separately to the sea. The clear water from the basin was discharged through the outlet at Castiglione which was provided with the necessary works.

First diversion canal.

(10) In 1840 it became apparent that the roseate calculations of Fossembroni as to the time necessary for the completion of the work were not likely to be fulfilled, as it was found less easy than was supposed to conduct large volumes of water to silt up distant places, and moreover the water did not deposit the quantity of silt that had been calculated on.

(11) Fortified by this experience the enlargement of the diversion was carried out and its discharge increased from 1,250 cusecs to 16,700 cusecs.

First enlargement of the diversion canal.

The widening of the canal and other subsidiary works still did not produce the results hoped for, since there appeared defects in the weir and also in the regulator at the head, which passed heavy floods resulting in breaches of the banks and inundation of the country and much other damage. In addition to which, and for the same reasons, the canal ceased to function for no less than 18 years during the period 1830—72.

(12) In 1872 the Government of Italy appointed the Engineer Baccarini to make a full and comprehensive enquiry into the whole question of the improvement of the Maremma, and to suggest means adapted to push the necessary work on with more rapidity.

He found the diversion canal in such a condition that, instead of carrying the prescribed discharge of 16,700 cusecs as a maximum, it could hardly carry 3,800 cusecs in its lower portion, because the slope had decreased from 0·74 per thousand to 0·40 per thousand in consequence of the prolongation of the canal to 6·2 miles with the advance of the silting-up process. The silting-up of the bed resulted in frequent breaches and inundations of the surrounding country.

The system of drains, too, was found to be imperfect. They discharged their clear water into the marsh and hence reduced its capacity to receive the turbid water.

(13) His proposals were :—

(1) To provide the regulator with gates to prevent the floods of the Ombrone having a free ingress.

(2) To raise the banks somewhat and excavate the channel to allow of it carrying 10,700 cusecs as a maximum.

(3) To take off from the diversion canal several branches for the purpose of silting up different portions of swamps.

(4) To make further provision for the escape of the clear water and for the drainage of the country already redeemed.

(14) Although considerable improvements in the general conditions of the country were effected by the execution of the above works, still it very soon appeared that, in order to obtain more rapid results, it was absolutely necessary to utilize the largest volume possible of the flood water, so rich in silt, by sensibly increasing the section of the diversion canal; and in 1894 a fresh project, with this object in view, was prepared and put into execution in 1901.

Second enlargement of the diversion canal.

(15) The aim of the project is to utilise completely floods in the Ombrone up to 12,900 cusecs and proportionately those of higher floods up to a maximum of 21,000 cusecs, to remodel the regulator by giving it 6 bays of 4·66 metres (15· 3 feet) span and to raise the weir by 1·10 metres (3·4 feet). Also the amount of super-elevation of the lands under colmata, and of those already raised was increased to allow for a settlement greater than was first anticipated.

It is now hoped that on the completion of these works, which are still under construction, that the colmata will be completed in 20 years.

(16) The reasons which led to the complete failure of the Engineers Fossombrone, Manetti and Baccarini in their predictions as to the time necessary to complete the work were as follows :—

Reasons of past failures.

(1) The amount of silt, *viz.*, 5 per cent. of the volume of the water as calculated, was not actually deposited.

(2) The soil of the marsh was compressed by the silt deposited on it so that, as direct observations and calculations have already proved, two-thirds of the volume of silt deposited since the commencement of the works have, so to speak, disappeared.

Area under colmata.

(17) The tract under colmata has an area of 9,094 acres and is divided into two parts by the Canal di Molla and Collectore, *vide* Plate No. 6.

In addition to the 9,094 acres within the basin of Castiglione swamp, there are 4,446 acres on the right and 5,253 on the left of the diversion canal which have already in part been raised and which will again have to be raised owing to the settlement that has taken place. The total area is therefore 18,793 acres, or 29·7 square miles. In the part to the left the more important are the three silt tanks called "della squadra alta del termine," the open marsh, and the "della strillaie;" the Fossi dei Pescatori and the Emissario S. Leopoldi separate the first two. They receive the turbid water of the diversion canal which has its mouth in the open marsh, whilst the clear water is turned into the river of S. Leopoldi and Castiglione.

The part on the right constitutes the basins of Barbaruta and Raspollina between the Bruna, the Canal di Molli and the Collectore. The basins of Barbaruta and Raspollina and Castiglione delle Pescaia receive the silting water of the Ombrone from the regulator head, whilst the clear water is carried away into the plain of Castiglione.

Details of third enlargement.

(18) The enlarged canal has a slope of 0·415, so that the bottom, which is given a width varying from 23 to 48 metres (75 to 157 feet) in a length of 10 miles, should not be below the plane to which the land is to be raised. The section of the diversion canal is designed to avoid or at least diminish silting up; and the object of the cunette is that silting-up should not take as the water in the canal falls. Fig. 3, Plate 7, shows the cross-section of the canal as now being enlarged. The maximum depth of water in the canal will be 6·8 metres (22·3 feet), the average depth of water 4·5 (14·7 ft.)—the minimum about 3·0 metres (9·8 feet). With the maximum depth running into the canal the mean velocity will be 2·2 metres (7·2 feet) per second, which seems very high for an earthen channel even when the banks and bed are of fairly stiff clay.

It must, however, be remembered that the canal will run with full depth only occasionally and, moreover, the water contains such an enormous amount of silt that its power of scour is diminished. The canal will be worked between the 6 months November to April, these being the months when the greatest amount of rain falls. The average number of floods during these months is about 12, and their duration 4 to 5 days each.

(19) Fig. 2, Plate 7, is sketch-plan of the diversion canal at its off-take and Fig. 1, Plate 7, a sketch of the cross-section of the weir.

Canal head.

(20) The canal head or regulator is built a little distance below the canal off-take, owing to the presence of a rocky barrier here which extends across the line of the canal.

The head is now being rebuilt to suit the present enlargement of the canal. It will have 7 spans, 4·5 metres (14·7 feet) wide by 6 metres (19·7 feet) high, which will be fitted with lift gates 4·6 metres (15·0 feet) wide by 7 metres (23 feet) high. The gates will be of iron plates with I-beams at the back. The friction in the grooves will be diminished by a series of wheels in pairs continuously lubricated by means of a special system of pipes. They are made water-tight at the sides by means of a special arrangement faced with India-rubber. The raising will be effected through a chain actuated by an electric motor, and the power of the motor will be used also to assist the weight of the gate when lowering. It has been necessary to widen the existing road bridges, of which there are 5, and a new railway bridge at a higher level has been built.

(21) The total length of the canal from the off-take to its termination at the main basin, is 10 miles; at 5¼ miles from the head a branch canal takes off on the right with a discharge of 8,900 cusecs to silt up a depression there. When this has been completed this volume will be passed on to the main basin, the canal works and the section having been designed to admit of this being done. At 3¾ miles from the head the canal bed is about 1 metre below ground level and continues at about this level up to the main basin, so that the diversion canal is, for the great part, a huge embanked channel.

(22) With the full discharge of 21,000 cusecs, it is estimated that the silting basins will be filled in 1½ days. The water will ordinarily be allowed to remain 10 days or so in the basin and will then be slowly drawn off from the top. It will take about 2 days to empty the basin.

(23) Up to the present time the clear water has been discharged into the sea by means of low weirs situated in the marginal embankment, and protected with

fascines. It is, however, now intended to construct suitable masonry escapes for the discharge of the clear water.

(24) The depth of water in the basin when full will be from 2·5 to 3 metres (8 to 10 feet) as a maximum. The amount of silt still to be deposited within the area of the Castiglione swamp is estimated at 50,000,000,000 cubic feet, and 50 years is the period now estimated for the completion of the work and, if this is fulfilled, the total time from the initiation of the work in 1829 will have been no less than 170 years.

(25) The maximum flood discharge of the Ombrone is 85,000 cusecs. The amount of silt carried in suspension by the Ombrone is very great, as stated by the engineers it is $\frac{1}{10}$ by volume, *i.e.*, 10 per cent. as maximum; but it must be remembered that it will be very much compressed when deposited and, as deposited, the proportion will probably be reduced to about 6 per cent.

(26) The swamp of Piombino at the beginning of the XIX century was included between the sand dunes along the gulf of Piombino, the slopes of the hills of Populonia and the Via Aurelia.

Piombino swamp.

Into this depression the Cornia river and the torrents from the hills empty themselves, *vide* Plate No. 6.

(27) But little was done prior to 1827, when the Engineer Giorgini proposed to prevent the salt and sweet water mixing, the improvement of the drains and the utilization of the rich silt in the Cornia for the purpose of colmata of the low lands, and the embanking of the upper course of the Cornia.

First proposal for improvement.

His proposals were completed by Manetti, and an outlet known as the "Ponti di Capezzuolô for the clear water of the Cornia and for the drainage water was constructed. This bridge was furnished with moveable gates to prevent the ingress of the salt water.

(28) In 1872 the Engineer Baccarini made further proposals, which were also carried out.

However, as both diversion canals from the Cornia up to then had worked very inefficiently, provision was made in 1899 for a new rearrangement of the basin by extending it to 2,156 acres and for a diversion of the whole volume of the Cornia into it.

(29) This river has a maximum discharge of 31,400 cusecs, and its mean turbidity is 1·5 per cent. by volume.

Discharge of the Cornia.

(30) Silt tests are made by taking samples of the water at the height of about 1 metre above the bed in a receptacle holding 1 litre. Beakers holding half a litre are filled with the turbid water and the silt is allowed to settle and is then dried and weighed.

Silt test.

A sample of silt was weighed before me and was found to be 74·6 grammes per litre. This works out in the proportion of 1 to 13·4, or 7·46, per cent. by weight. By volume this would be, taking a cubic foot or silt at 85 lbs. and a cubic foot of water at 62·4 lbs., 1 to 18·2 by volume or 5·5 per cent.

The maximum amount of silt as stated by the Engineer is 1 to 15 by volume or 6·66 per cent.

Silting process.

(31) As has already been stated, the whole volume of the Cornia now flows into the Piombino basin through the two diversions which are shown on the plan. These are gradually advanced as the silting up process takes place. The two diversions are divided by a bank in order to silt up more quickly the portion marked A on Plate No. 8, and to give the water issuing from the second diversion a longer course before it reaches the escape at Torre del Salle. The colmata is frequently helped by subsidiary bunds a, b and c, as per marginal sketch, in which weirs are formed protected with fascines to allow of the passage of the water from one compartment to another.

(32) There are on the average about 12 floods between the months of November and June, lasting about 12 hrs. each. The earlier floods are those which, as a rule, bring down the greatest quantity of silt, as at that period of the year the agricultural land in the hills has all been ploughed up, and the surface soil thus loosened is easily washed down by the rainfall.

Floods in the Cornia.

Mean floods run about 5·0 ft. and maximum floods about 13 ft. above the low water stage.

The Cornia is embanked on both sides and when in full flood, the water-level is 8 to 10 ft. above the level of the country.

(33) Levels are taken every year during the summer season to show that the colmata is progressing.

Depth and volume of silt deposit.

It has been calculated that over the whole area the depth of silt deposit per annum is 13 millimetres (1 inch).

The amount of silt collected between 1894—1899 was 570,000 c. metres, and as it has been estimated that 3,400,000 c. metres are still required: a period of 30 to 35 years will be necessary to complete the colmata.

The present basin contains 9 million c. metres, and as a high flood is calculated to give 20 million c. metres, it is intended to increase the area of the basin to take in nearly the whole.

Amount of raising.

(34) In order that the land may, after the completion of the colmata, drain properly towards Torre de Salle, the level to which the land must be raised at any particular point A from Torre de Salle of which the ordinates are X and Y with respect to that point, is given by the formula.

$H = 0{\cdot}95 + 0{\cdot}05\ X + 0{\cdot}10Y + 0{\cdot}30.$

0·95 being the height above sea-level at the sea.

0·05 the maximum slope per thousand to main drain.

0·10 the maximum slope per thousand to secondary drain.

0·30 the allowance for settlement.

Escape for clear water.

(35) There are two works for the discharge of the clear water at Cappezuolo.

One consists of 4 drop gates of 5·0 feet span revolving on the lower axis and raised or lowered by means of a travelling crane: the sill of the escape is 1·6 feet above mean sea-level. By means of this escape the water can be gradually drawn off from the surface. The second escape has a span of 13 feet, with its sill 3¼ ft. below sea-level, for the purpose of drawing off all the water in the basin.

The works at Torre de Salle for the same purpose are :—

(*a*) a similar escape to the one at Cappezuolo for drawing off the surface water, (*b*) an escape of 4 spans of 5·0 feet each for drawing off the water to the lowest level, (*c*) a weir made of wood and fascines 440 feet long for the discharge of excess water brought into the basin.

Duration of the colmata.

(36) The work has been in progress since 1828 and is not likely to be finished, according to the most recent estimate, until 1938 (about) so that 110 years in all will have been occupied in reclaiming this marsh. It must be noted here, however, that a certain area has already been completely raised and is now under cultivation—how much cannot be accurately ascertained.

Cost of improvement works in Tuscan Maremma to date.

From the initiation of the work up to 1905-06 a sum of Rs. 2,04,00,000 has been spent on land improvement works in the Tuscan Maremma.

Bonificazioni at Ravenna.

Description of the improvement of lands in the valley to the north of Ravenna by means of silt—

(1) An excellent example of the system of the improvement of land by means of silt deposited on it is to be seen in the silt basin of the Lamone. Here the valleys of S. Egidio, Mezzano, Savarna, and S. Vitale have already been transformed, for the greater part, into most fertile land, *vide* Plate No. 9. During an extraordinary flood on 7th December 1839, the Lamone burst its right bank in the locality called Ammonite near Villa Santerno, the breach was 250 metres (820 feet) wide and the river channel below the breach was so damaged that it was found impossible to turn the river back into it without the execution of costly works.

Thus, by the force of circumstances as it were, commenced the improvement of the land now to be described.

Proposals of the first Commission.

(2) A commission assembled in 1840, to decide on a plan of action, recommended, since the idea of closing the breach could not be thought of, that the course of the waters should be inclosed between banks 650 feet apart. This is called on the plain "Allaciamento," or leading channel 2½ miles in length, and by it the water is carried on to the low-lying lands. The whole area over which the waters are allowed to expand has been surrounded by a marginal bank.

(3) The Commission also settled to what height the levels within the basin should be raised. It fixed a height of 1·34 metres (4·4 feet) above the zero of the gauge at Porto Corsino, *i.e.*, above mean sea-level, *plus* 0·10 per thousand, according to the distance of any point from the sea, measured on the shortest line of the drainage. The slope thus given to the lands allows of their readily draining on the completion of the colmata.

The Commission finally proposed, after the completion of the Colmata in this valley, that the Lamone should be turned into the Podi Primaro, and that this latter should be diverted into the Reno upstream of S. Alberta.

(4) In order to indemnify the proprietors of the lands within the basin they were allowed to cultivate rice, and were permitted to put up secondary little bunds for the protection of the tracts placed under rice cultivation. They were also allowed the summer water in the river for its irrigation, the just and equitable division of the water being left to the public authorities.

Rice cultivation within the basin of the Colmata.

(5) Plate No. 8 shows the state of the basin or silt tank as it was originally planned and carried out in 1840—44.

The drains Fiametto, Bendazza, Fossatone, Tuglia Nuovo carried away the clear water from the basin into a canal which discharged itself at Porto Corsini. No steps, however, were taken to direct the silt-laden water within the basin in such a manner as to properly silt it up, the basin was looked upon merely as a basin for the provisional expansion of the water of the river in the attempt to systematize the course of the Lamone, and not for the purpose of the improvement of the lands within it.

(6) This state of things was the cause of many complaints and led to the appointment of a second Commission in 1846, which laid down rules for the regular distribution of the turbid waters within the basin. These were followed with excellent results. Plan No. 9 shows the course of the "Allaciamento," the banks of which were gradually raised and extended. Minor channels were taken off from the main to carry the turbid water to outlying parts.

Proposals of the second Commission.

(7) One may here note that, when the marginal bank was constructed, there was a good deal of opposition on the part of the canal proprietors to the inclusion of lands, which though then low-lying with respect to the sea-level were nevertheless under dry cultivation, because they were readily drained. They did not understand that when the Colmata was completed these lands would be too low to drain away to the sea and would therefore become swamps.

(8) In 1869 the raising of all the lands on the right bank of the Allaciamento up to the road of S. Alberta was completed and such lands were cut off from the rest.

Progress of the Colmata.

The area thus cut off was 4,310 acres out of a total 17,761 acres, besides which another 2,704 acres were nearly finished.

(9) In 1871, the diversion *Frata* was opened out, but it was soon recognized that, by raising the lands in this direction, a ridge would be formed which would cause difficulties with the future drainage of the tract from W. to E. In 1898, therefore, the old breach was closed, the old bed of the Lamone brought into use again for another 2½ miles and a new Allaciamento was opened.

With the addition of other lands which were added from time to time, the total area was increased by 1,976 acres. In 1898, 11,920 acres were completed and cut off. These lands were provided with a proper drainage system having their outlet in the main drain leading to Porto Corsini.

The area within which the waters could now expand became much restricted, and, after the construction of the new Allaciamento the following works had to be carried out :—

(1) Marginal banks were carried on the left and right up to the road of S. Alberta.

(2) To facilitate the flow of water across this road an opening spanned by a wooden bridge, 330 feet long, was opened and two other openings elsewhere made.

(3) The section of the drain Fossatone, through which the clear water of the basin found its exit at Porto Corsini, was doubled, as also that of the drain Taglio, another outlet for the clear water.

(11) In order that the silting-up process should proceed regularly from upstream downwards, two branch channels were opened up to the right and left of the mouth of the new Allaciamento.

These two branches remain open from October to April in each year—*i.e.*, during the period of floods, of which there are 5 or 6 on the average.

For the remainder of the year they are closed by bunds to permit of rice cultivation, which is irrigated by means of special masonry heads in the river bank from the summer flow in the river, which is carried away to the sea in another channel.

(12) When the colmata of the lands near the mouth of the new Allaciamento has been completed the banks will be prolonged towards the road of S. Alberta, and the present banks will also have to be raised as the levels rise.

The basin will also have yet another 1,580 acres added to it.

(13) As the area of the basin will become more and more restricted it will soon be necessary to consider how the danger of inundation of the country and of the silting up to Porto Corsini can best be obviated.

This difficulty will probably be met by the diversion of the Lamone along its old bed with the Po di Primaro up-stream of S. Alberta : this however has not yet been definitely decided upon.

(14) This is a notable example of the ruin of the hills, through inconsiderate disafforestation becoming the good fortune of the plains.

(15) The surface of the Appenines, bare and uncultivated, is easily and rapidly eroded by the rainfall which finds its way into the Lamone, and its tributary the Marzeno, and through them into the Ravenna valley, which valley in ancient times was the defence of the city against barbaric hordes. To-day this valley, thanks to the silt-laden water of the rivers mentioned, is gradually being brought back to cultivation of a very high order.

Flood discharge the Lamone.

(16) The Lamone has a drainage basin of 204 square miles, of which 183 square miles, or nearly 90 per cent. are in the mountains. The slope in the plains portion is 2·5 per thousand, and the flood discharge is 12,500 cusecs.

Embanked rivers.

(17) The river is highly embanked, as also are the Savio and other rivers of this tract.

In some cases the beds of these rivers are above the level of the country ; generally, one may say, the water surface in the summer is at country level about, and flood level some 6 to 10 feet higher.

The marginal sketch gives a section of the bank of the Lamone where it has to be protected with stone pitching ; across hollows, where the banks are specially high, a berm is generally added on the outside.

In spite of the high level at which these rivers run there is no percolation in the lands near the outside slopes, owing to the compact and argillaceous nature of the soil.

(18) The amount of silt carried in suspension by the waters in the Lamone is stated by the Engineers to be as follows :—

Average	...	3-5 c. metres per 100	c. metres of water.
Maximum	...	10 ditto	ditto.
Though in one case was found	...	15 ditto	ditto.

It must be remembered that this proportion has been arrived at by measuring the depth of silt deposit in cylindrical glasses containing, say, $\frac{1}{2}$ litre (0·88 feet) of turbid water : when deposited it will shrink owing to compression by about $\frac{1}{8}$.

(19) The fertility of the silt deposited by the Lamone is great, and constitutes an immense reservoir of nutrition, as it were, for plant life.

The following analyses were made by Signor Commandator Pasqui and Prof. Pasqualini in 1879 and 1877. The data show the mean results from 5 samples of silt from the Lamone : the mean results from 6 samples of the silt of the Savio are also added for the purpose of comparison.

It must be pointed out that there is a sensible difference in the quantity of clay and silica, according as to whether the samples were taken near or at some distance from the inlet ; the first contains more silica than the second. It is also evident that the ingredients—clay or sand—will vary according to the greater or lesser intensity of the floods, and it must be noted that the Lamone runs down from the rocks of the Eocene period, while its tributary, the Marzeno, from the rocks of the Miocene period ; and according as one or other is in flood, so does the nature of the silt, in the waters below their junction, vary.

(20) The following table shows how the water itself carries out the process of mechanical separation or levigation. The first sample of the silt of the Lamone was taken close to the stream entering the basin, the second at 1,200 feet to one side, the 3rd, 2,600 feet, the 4th at 3,600 feet, the last at 4,800 feet.

	Samples.				
	I	II	III	IV	V
Sandy matter	20·40	19·04	16·80	15·30	15·00
Clayey do.	79·60	80·96	83·20	84·70	85·00
	100·00	100·00	100·00	100·00	100·00

Chemical analysis of the silt of the Lamone and Savio.

(21) The analysis given does not, however, show the amount of nitrogen. The amount of phosphoric acid in the case of the Savio would in itself show the silt from that river to be the more fertile ; but this fertility does not depend, as is well known, on the chemical analysis alone, but also on its physical and hygroscopic properties, the proportion in which the earthy ingredients are mixed, good drainage, thickness of culturable stratum. These together will form a soil

of the highest fertility. The silt-deposited lands of the Lamone are in practice found to be superior to those of the Savio, Ronco, etc.

Prof. Tornani, too, has made the following mechanical analysis of the Lamone silt which is in somewhat greater detail.

In 100 parts of earth dried in air :—

Coarse sand	Calcareous ...	...	8·292	29·505
	Silicious ...	...	20·768	
	Organic matter ...	...	0·444	
Fine sand	Calcareous ...	...	18·689	46·714
	Silicious ...	...	26·014	
	Organic matter ...	...	2·011	
	Clay ...	...	11·705	
	Humus ...	...	0·286	
Hygroscopic water		...	5·175	
Other soluble substances not determined		...	6·615	
	Total	...	100·000	

(22) The average outturn from these silt-deposited lands is as follows :—

Wheat quintals 18—22, 26—32 bushels per acre.
Beetroot quintals 400—500, 16—20 tons per acre.
Spanish hay quintals 90—100, 3½—4 ditto.

The predominant cultivation is thus approximately distributed :—

6/10 to 5/10	Artificial meadows of leguminous plants.
3·5/10 to 4·5/10	Wheat.
0·5/10	Beetroot.

(23) Large quantities of artificial manure are used. The mean consumption of Scoria Thomas, mineral super-phosphates and bone super-phosphates is 1·2 cwt. per acre.

(24) There is no doubt that a large amount of highly productive land has already been and is in course of being added to the country-side round Ravenna by means of the silt-laden waters of the Lamone and Savio. Production has increased, and greater production means more trade and greater employment of labour and capital. The hygienic results of the works both to Ravenna itself and the densely populated tract around it have been great.

Financial results of colmata.

(25) The financial results of this work of Colmata with the silt of the Lamone must now be examined.

The expenditure is as follows. It includes the construction and maintenance of the banks of the Allaciamento and of those round the basin, the construction and maintenance of the works, the opening of new channels for silting purposes and for drainage, compensation to proprietors—in fact everything which relates to the work under construction :—

		Rs.
1840-48	...	3,46,416
1849-71	...	10,82,214
1872-1903	...	18,74,790
Total	...	33,03,420

It is, however, necessary to consider what amount would have been spent on the maintenance only of the banks of the Lamone, which in any case must have been incurred.

This is calculated at Rs. 10,74,311 for a length of 14 miles. If this amount is deducted the total expenditure up to 1903 will be Rs. 22,29,109, or Rs. 187 about per acre, since the area completed is 11,920 acres. The cost per acre of the remaining 8,131 acres will be less, as the works for the most part have been completed.

(26) Before the initiation of the improvement the land values were Rs. 73 to 85 per acre ; now lands in the valley with the prospect of being improved are worth Rs. 170, and lands already improved Rs. 267—291 per acre, the difference depending on the presence of habitations and drains.

The interest on the capital expenditure may be considered balanced by the return from the cultivation of rice which was rendered possible by the use of turbid waters.

We have therefore price of valley land Rs. 73 to 85, *plus* cost of improvement Rs. 187 = Rs. 260 to 272 (about) per acre, which is about the present value of land. The land is highly productive and yields a net revenue of Rs. 50 to 60 per acre, or even more, so that it can be asserted that the speculation has been a successful one.

(27) Cost of earthwork in main drain; including excavation to 6½ feet below water-level, Rs. 16·8 per thousand. Labourers get Rs. 1·6 per diem and will excavate 178 to 213 cubic feet per diem.

		Silt of the Lamone, 1877.	Silt of the Lamone, 1879.	Silt of the Savio, 1877.
Mechanical analysis.				
Coarse sand		17·31	16·344	15·44
Clay and very fine sand		82·69	83·656	84·56
Total		100·00	100·00	100·00
Soluble matter. *In* 100 *grains of earth dried at* 110° *C.* in distilled water at +15°	mineral ...	4,701 } 6,601	48,60 } 6,621	5,111 } 6,382
	organic ...	1,900 }	1,761 }	1,271 }
in water saturated with carbonic acid at +15° ...	mineral ..	6,514 } 8,323	6,444 } 7,917	6,864 } 8,533
	organic ...	1,809 }	1,503 }	1,667 }
in boiling hydro-chloric acid,	mineral...	29,041 } 30,559	16,841 } 18,550	29,803 } 31,292
	organic ...	1,518 }	1,709 }	1,489 }
In 100 *grains of earth dried at* 110° *C.* Organic substance and water		2,770	3,275	2,869
Matter soluble in boiling hydro-chloric acid.				
Oxide of calcium		11,136	11,853	10,822
Oxide of potash		0,631	0,488	0,513
Phosphoric anhydride		0,160	0,147	0,240

Improvement by Colmata of the Ragazzena Holding.

This is an interesting example of the improvement of land with the silt of the Savio river conducted by the proprietor himself, *vide* Plates Nos. 10, 11 and 12. The work of improvement was begun in 1870 and the land which required raising is shown in the Plate No. 11—the heights in this plan show the relative heights with reference to a fixed datum.

Colmata Channel.

(2) The channel has a bottom width of 3 metres (9·8 ft.) and a slope of 0·36 per 1,000 and is 1¼ miles in length to the further boundary of the property. The head has a single opening of 1·6 metres (5·3 ft.) with a height of 3·05 metre (10 ft.) up to the soffit of the arch.

The head is furnished with heavy wooden drop-gates working in wooden frames, one on the up-stream and one on the down-stream side. These gates are raised by means of levers working in an iron rack fixed to the back of the gate. Double gates are a necessary precaution, as the surface level of high floods in the river is several metres above the level of the country.

(3) At the commencement a marginal embankment was constructed all round the property, together with a ditch for the collection of the clear water which was connected with the main drain "Scolo consorziali."

The land to be raised and improved was divided into 6 basins as follows:—

1.	Cassa stralciata	12½ acres.
2.	,, nuova	30 ,,
3.	,, di campi	75 ,,
4.	,, superiori	62½ ,,
5.	,, della casa	57½ ,,
6.	,, valle	67½ ,,
	Total	305 acres.

Each basin was provided with a suitable ditch for carrying the turbid water and another for the drainage of the clear water after the silt has been deposited. The spaces between were divided in a suitable manner with low ridges, to facilitate the process of Colmata and the cultivation of rice which is associated with it. Every year new basins are provided for the turbid water, whilst wet cultivation is carried on in the old ones. Rice is not put in the same ground more than two years in succession, in order to allow of another layer of silt being put on; by this process the land is gradually raised.

(4) In Plates Nos. 10 and 12 are shown the heights of the land, both before being raised, and also at the present time, with reference to the zero of the gauge at Porto Corsini. A comparison of these two will show that the maximum depth of deposit has been 5·0 feet.

(5) The Government laid down the following general rules for the bonifica of the Lamone basin. At the sea the land must be raised to a level of 1·34 metres (4·4 ft.) above the zero of the gauge, *plus* 0·10 per 1,000 according to the distance measured on the shortest line on any point from the sea. By this rule 1·34+·8 ×·10−2·14 metres (7 ft.) would suffice here, but this has been already exceeded

in several basins. As it is certain the land already raised will settle somewhat, it is not intended at present to relinquish the work. However, when the land has reached a height sufficient to afford easy drainage, the silt basins will be abandoned and only those maintained for wet cultivation which will require a small film of deposit annually.

(6) The little basin near the Ragazeena road has been cut off from the rest and planted with trees and vines, the others are worked in rotation by alternating wet cultivation with that of meadow and wheat.

(7) The system followed, in addition to the general raising of the land and the filling up of hollows, has given splendid results. Chemical manures are largely used. Chinese rice has given a return of 1 ton per acre, Rangoon rice 1·8 ton per acre. The meadow land has given a return of Rs. 65 per acre without taking into account the fact that 267 pounds of seed have been harvested, giving a total return of about Rs. 97. Wheat has given as much as 40 bushels per acre.

The colmata has not only been a success financially, but has also resulted in the hygienic improvement of the locality. In the summer months irrigation is carried on with the clear water in the river.

(8) As soon as this holding is put into good order the channel will serve the lands beyond its boundaries.

(9) Owing to retrogression of levels in the bed of the Savio it became difficult to get in a proper supply, especially when the little summer floods occurred, which are particularly rich in silt.

Water was originally diverted into the head by means of a bund, but recently, a small weir has been built in the river below the head.

This is fitted with automatic gates which fall as soon as the flood water tops them.

(10) The system here followed in applying turbid water to the lands is exactly similar to the irrigation of rice fields in India. The compartments, or *kiaries* with *mendhs*, about 1 foot high are filled with the turbid water, which slowly passes from one compartment to another over the tops of the *mendhs* or through small gaps in them, and when the water is quite clear it runs off into the drains.

SECTION III.

Colmata di Monte.

(1) The system of reclaiming ravines and stopping erosion in the hills is known as "Colmata di Monte."

This work has for its object the utilization of the force of the waters for the removal of the objectionable ruggedness, whether concave or convex, and for modifying or rendering the slopes more uniform.

The waters act in a double manner—

(1) by eroding the projections or convexities and carrying away earth from them;

(2) by transporting and depositing the silt in the depressions or concavities.

(2) The most perfect system of colmata di monte yet devised is that worked out by Agostino Testaferrata, who was the agent on the estate of the Marquis Cosimo Ridolfi at Mileto from 1793 to his death in 1822.

(3) This estate (some 1,500 acres in extent) was visited by us for the purpose of studying this system of colmata, for it is still in progress here and has, therefore, been going on for nearly 100 years.

(4) I was very much struck with the really marvellous results obtained with the simple means adopted. The value of the estate has risen immensely owing to the work which has already been carried out.

(5) In order to explain the system I will first give a general account of it, together with an example which has been taken from "La Sistemazione e lo scolo delle acque nei terreni in Collina" by Dott M. Conti.

This describes not only the work of colmata in the ravines in a general way, but also the system of dealing with the slopes between these ravines by the method which is called "La Sistemazione a Spina" which follows the former.

(6) I will then give an account of a portion of the work carried out at Mileto, which has been taken from "Le Coltivazione di Poggio," by Luigi Ridolfi.

This description relates more particularly to the work of colmata in the ravines themselves.

(7) The following account of the systemization "a spina" is taken from Dott M. Conti's work on "The systemization and drainage of water in lands situated in the hills."

(8) In order to give some idea of the valuable matter carried away by drainage water and the damage this latter actually causes, the following chemical analyses are given, both of the soil of hills of a somewhat argillaceous character and of the silt carried away by the streams running off them during a period of heavy rainfall.

Valuable matter carried away by drainage water.

	Soil in the hills.	Soil carried away.
Vegetable matter	0·2 to 0·8 per cent. ...	1·3 to 1·6 per cent.
Clay	40 to 70 ,, ...	70 to 80 ,,
Sand	30 to 60 ,, ...	20 to 30 ,,
Lime (constituting 70 per cent. of the sand)	35 to 40 ,, ...	20 to 25 ,,

(9) In 100 parts of fine soil dried in the air.

	Soil in the hills.	Soil carried away.
Moisture	3 to 5 per cent. ...	4·5 to 7 per cent.
Loss from calcination (deducting the moisture).	2·7 to 55 ,, ...	4·5 to 8 ,,
Organic carbon	0·4 to 0·8 ,, ...	4·5 to 8 ,,
Equivalent amount of humus with 58 per cent. of carbon.	0·69 to 1·37 ,, ...	2·84 to 4·25 ,,

(10) In 1000 parts of fine soil dried in air.

	Soil in the hills.	Soil carried away.
Organic and inorganic nitrogen ...	0·9 to 1·12 per cent. ...	1·26 to 1·68 per cent.
Phosphorus anhydride	0·6 to 1·2 ,, ...	1·6 to 2·1 ,,
Oxide of potassium	4·4 to 6·9 ,, ...	6·4 to 8·3 ,,

(11) The above analyses are the mean results of several samples in each case and are worthy of examination. The land in those hills which is poor in matter useful for plants and very poor in humus is so washed by the rainfall that, in the course of time, it becomes absolutely deprived of those elements which are the prime causes of the fertility of the soil.

(12) The rainfall in descending from the hills to the plain tends to collect in the more depressed parts of their surface and is the cause of damage, because here, more than anywhere else, the water begins to cut channels which, in the course of time, become ravines. The effect is more rapid when the land has not time to absorb the rainfall in sufficient quantity to confront the drought of the warm season. The evil results are less felt in lands which are light and capable of absorbing a portion of the rainfall.

In general the hills in Italy are composed chiefly of clayey earth which has little permeability.

(13) Professor Sisteni stated, when discussing the value of the silt carried by the Arno, that the analysis shows that one quintal of sediment left by the river Arno contains, when dried in air, about as much azote (organic and inorganic nitrogen) potash and phosphoric acid as would be obtained in half the amount of stable manure.

It is certain, he writes, that an *irriyation* made at due time and in a favourable locality can carry on to the ground a quantity of fertilizing elements, comparable with those which would be supplied by the purchase of matured stable manure, independently of the raising of the soil and of the advantages of controlling drainage.

(14) The following analyses are taken from Durand Claye's Agricultural Treatise :—

	River Nile.	River Durance.
Azote	0·17 } 16·10 ...	0·07 to 0·13 } 6·65 to 8·40.
Combustible matter	15·90 }	0·56 to 8·27 }
Lime	1·34 } 83·90 ...	20·30 to 29·95 } 93·37 to 91·60.
Aluminum clay and ferric protoxide ...	22·82 }	4·25 to 5·65 }
Phosphoric acid	0·42 }	
Other matters	59·32 } ...	68·82 to 70·10 }

The Durance alone is estimated to lose in the sea more than 14,000 tons of azote, equal to about 35 million quintals of stable manure.

(15) The difference between colmata in the plains and in the hills is that, in the former case, the silt already collected in the stream and torrents can be made use of, while in the latter case the rainfall on the surface of the hills only can be used

(16) Water acts in a twofold manner—that is to say, on the one hand it erodes the prominences and so becomes rich in earthy matter, and on the other hand it deposits this in such a way as to level up the depressions.

(17) It will be at once understood that the possibility of putting into practice the work of " Colmata di Monte " depends largely on the physical and mechanical nature of the soil.

It is possible, in fact, in hills of the tertiary formation (clay variously coloured and stratified with yellow sand) and in general everywhere where there is a soil which can be eroded and carried away by running water to be deposited again in more or less minute particles, as soon as the water moderates or loses its velocity entirely.

(18) A general practical rule in carrying out " Colmata di Monte " is the following:—That, when the slopes have been excessively eroded by the action of the water, one must commence by consolidating the base—*hence colmata must always be begun from the base.*

(19) The work of colmata cannot be considered as a thing by itself but in relation to the systemization " a spina " which must follow it.

It is not possible, therefore, to treat the two arguments separately, as they are so intimately connected.

The work of colmata can be initiated also some years before the tracing of the systemization " a spina " and especially where there are large hollows to silt up or there are hindrances such as plantations.

This work of colmata must be carried out, however, in such a way as to render a better tracing of the systemization " a spina " possible.

(20) It will always be assumed in the following description that a start will be made with lands already under cultivation, presenting however, either naturally or on account of a bad system of working the land, well marked superficial irregularities which have destroyed the surface and have rendered agricultural operations and communications difficult.

(21) It must be noted before proceeding further that, both on the initiation and during the progress of the work, great care and circumspection are required, and these can only be gained by practice and long experience.

Study preparatory to the construction of the basins of colmata.

In addition to the plans, and an intimate knowledge of the place where the work is to be done, a well trained and experienced eye, with acute powers of observation, are necessary in order to be able to foresee at the outset the best way to carry out the systemization from beginning to end.

A contour plan of the land will be of great assistance. It should be on a scale of not less than $\frac{1}{2000}$ with contours at every metre difference in level.

(22) The waters which, during the systemization, must act so as to erode and deposit earth must, when the work is completed, do neither.

As the work of settlement proceeds their action must be moderated, so that when it is finished they cannot only no longer alter the surface, but even run so as to preserve it.

(23) The way in which the contours run will give a clear idea of the superficial configuration of the hill.

Arrangement and disposition of the work of colmata.

In following them with the eye one can distinguish the great changes, in this connection which must, without fail, be maintained, and also all the secondary changes, which must be removed by the judicious work of colmata.

(24) Here the difference between colmata and colmatelle must be explained. The former is the work of removing the more pronounced irregularities, the latter the work of filling up the little valleys or slight depressions.

Difference between colmata and colmatelle.

Plate 13, Figure 1 will render this clearer. Colmata is the work of filling up the marked depressions C. C. and colmatelle the work of filling up the slight depressions c.c. This latter will be referred to in treating of the systemization " a spina " because it is one of its principal advantages.

(25) The basins of colmata are simply formed by bunds placed for the purpose of bridling the course of the water.—Plate 13, Figure 2. These must be so situated as to correspond respectively to one of the circulating ditches of the systemization " a spina " whenever this is carried out; and more precisely each of them must be placed immediately above the profile of such a ditch to avoid the risk of the bund being breached.

Construction of the basin of colmata.

The basin and the bund together form the system of colmata.

(26) The dimensions of the bund must not be cut too fine, otherwise a breach may occur. The earth must be placed in layers and well consolidated, and the bund should be well let into the hill-sides.

The bund should be a low one to start with, and raised gradually by successive layers as the silt is deposited in the basin at its rear.

(27) Each basin must have an inlet and outlet; the first for admitting the turbid water, and the second for letting out the clear water, which would otherwise flow over the bund. Water passes from one basin to the other, the inlet and outlet being generally arranged on opposite sides. The arms of the ditches, carrying water and called regulators, are directed down the shoulders in order to scour away such prominences. The silt-carrying ditches require to be cleaned out from time to time.

The water will run from one basin to another in a zig-zag course and do its work in a more or less automatic manner.

Maintenance of the work of colmata.

(28) Once the colmata has been rationally constructed, but little annual maintenance of the basins of the colmata, of the colmatelle or of the overflow weirs, etc., will be required in comparison with the great work, which has been performed by them in such an economical manner.

(29) The silt carried into the basins tends to transform them into a flight of steps as it were, while uniform planes are required.

Every year, when convenient, these basins should be cleared. This is generally done in the summer time. The work-people then throw part of the silt on the banks in order to raise them and part on the downstream toes to strengthen them.

(30) In order to make greater use of the power of the water, which runs down the hill, one sometimes has recourse to the construction of a small lake, and as far up the hill as possible wherever a suitable site can be found. This lake will collect the rainfall of the hill above it. It is easy to perceive that on the score of economy one must choose a hollow in the land. This hollow will be encircled on its lower side by a strong bund provided with several outlets, so that a good volume of water can be diverted in any direction for the purpose of eroding the prominences of the soil—the depression, of course, in which the lake is formed also, in the course of time becomes filled with silt.

(31) In other cases where the lie of ground is not suitable for the construction of a lake a contour ditch is made for the same purpose.

(32) The work of colmata here described tends to remove the greater irregularities of the surface, which, more than anything else, hinder the tracing of the systemization "a spina."

The tracing of a systemization "a spina."

In establishing a systemization "a spina" certain conditions must constantly be satisfied, without which it will not be possible to obtain all the advantages which the system possesses. The various faces, of which a hill is formed, must, above all, present a regular surface: if this is not the case, one must study, together with the project for systemization, that relating to the arrangement of the surface.

It is necessary to obtain such a regular surface by means of the work of colmata in order to form compartments of sufficient width and regular in form adapted to the better disposition of the trees and in order to render agricultural operations with animals both possible and easy.

(33) Access to the various parts of the farms for both men and animals must be easy; a good net-work of farm roads is therefore required.

(34) From the plan showing contours at every metre of level it will be possible to understand the lie of the surface and to draw the lines called *lines of the points of spina.*

These are drawn along the valleys and prominences and join therefore all those points on the curve where it changes its direction.

The tracing of the ditches will be easy from the fact that they will be delineated by the lines of the points of spina. The ditches must be parallel to each other, and at a distance representing the width to be given to the compartments.

This width depends on the inclination of the hill and should not be less than 12 metres (40 feet) or more than 20 metres (65 feet).

It will, however, be better to regulate the width on the following consideration, *viz.*, that the difference of level between two adjacent ditches should be from 3 to 4 metres (10 to 13 feet) according to the nature of the land in order to avoid either an excessive accumulation or an excessive run off of the rainfall from the various strips of land and in order not to have too high shoulders for the terraces which may afterwards be made.

(35) The slopes and the dimensions to be assigned to the ditches must be fixed in accordance with the nature of the soil and the quantity of rainfall to be got rid of.

The slopes should be between 0·5 and 1·0 per cent. and the dimensions of the ditch as follows:—

Depth 1·0 to 1·3 feet, width at base 1·0 to 1·3 feet and the width at top 1·6 to 1·8 feet. It seems hardly necessary to say that the larger dimensions are required for more compact earth and *vice versâ*; and that these dimensions must be increased

gradually towards the foot of the hill because a greater quantity of water is here collected.

(36) In tracing the lines of the systemization it may happen that the lines of the points of spina remain parallel. In this case ditches of equal length will result, and compartments easy to be planted in regular order and easy to be worked.

When the inclination of the land is uniform the compartments will be of equal width, but when its inclination varies the distance between the ditches must vary to maintain between them the limit of difference of level noted above.

On the completion of the tracing of the ditches the land is found to be systematized "a spina."

(37) When the contour curves show great variation relatively, that is to say, with the lines of the points of spina, the ditches are angulated. Now, when the angle is towards the person looking at it, it is called an *open spina*, and when its vertex is presented it is called a *closed spina*, *vide* Plate 14, Figure 1, which illustrates this.

(38) After collecting the water in these circulating ditches the best method to get rid of it from the fields and send it to the plains must be studied.

The ditches, which connect the circulating ditches, must be traced directly down the slope, but they cannot always be permitted to have an erosive action on its surface, for, when this latter is deprived of prominences to be cut away, or when it is excessively steep, artificial means will be needed to render the course of the water as little harmful as possible.

These connecting ditches must then either be taken obliquely down the slope, or furnished with banks or bridles from tract to tract, *vide* Plate 14, Figure 2, or in more unfavourable cases they must be pitched and provided with some little wells or cisterns to eliminate the force of the water in its descent.

(39) In commencing the study of the systemization it has already been remarked that it is necessary to design a good distribution of farm roads. Such roads, if judiciously laid out, greatly help the work of cultivation, as they give ready access to the various fields.

The farm road must not, however, be opened in the folds of the hills, that is, where the spina is open, because the water will run down there (as in the connecting ditches) into the cultivation causing erosion and damage.

The above rule must be strictly observed: but where, for special reasons, the cultivator must have a foot-path along a depression, he can always lessen the bad effect of doing so by reducing to a minimum the quantity of water which can flow away along it. The better course for the farm foot-path on the hills is, however, that offered by the lines of the points of spina traced on the prominences.

(40) Here ends the description of the work which can be laid down on the plan. In order to proceed to lay it out on the ground no special rules are required, only a little practice and a certain confidence with the ordinary instruments in use are necessary in order to be able to transfer all the particulars from the plan to the ground.

Laying out the systemization on the ground.

The corresponding position of the lines of the points of spina must first of all be laid down. The distribution of the contour ditches, their direction, and their distance apart is then marked out with stakes, and finally the position assigned to the farm roads and to the collecting ditches. When this is done all that remains is the manual work of excavating the ditches, according to the form and dimensions previously laid down.

(41) It has been assumed that the various straight lengths of the ditches have a uniform slope of about 0·5 to 1·0 per cent., so that the water can freely run from one extremity to another. But this is not commonly the case. In desiring to trace ditches of some length, numerous impediments, caused by the irregularity of the surface, are found along the alignment.

Work of colmata.

From a cursory examination of Plate 14, Figure 3, it will be seen that when one wishes to trace ditches of a given slope between the two lines of the points of spina *a b* & *a′ b′* one must make them follow the tortuous lines of a contour. If the ditches are given a straight line course their slopes will be variable, and water will tend to collect in the depressions. For example, the water which should go from *a* to *a′* will not be able to do so because of the prominences *r. s. t.*, and will tend to run along the depressions because it is hindered from rising from one part to the other.

The work of colmata must aim at removing such irregularities. Little banks on the downstream side of the single ditches are constructed corresponding to the points *c c′ c″* and banks of a more solid description corresponding to the points *c c′ c″*. We have then in *c c′ c″* colmatelle and in *c′ c″ c″* colmata with a true system of silt basins.

With regard to these last one must follow the rules already laid down, but with regard to the colmatelle there is but little to do, and that not very costly. For the construction of the little banks the earth excavated in the circulating ditches

is used ; the height will be limited at the start and will be increased in successive layers afterwards.

The work of maintenance reduces itself entirely to good regulation and to the best manner of utilizing the water coming into the basins.

In fact, the water in passing from one to another of the basins must be made to run across the prominences (in this case *r.'s. t.*) in order to carry away earth from them to the depressions.

Plates 15 and 16 will give a clear idea of the simultaneous work of systemization and colmata.

They show two hill-sides, one facing south and the other north of the same hill.

The work of systemization with the tracing of the circulating ditches, the silting ditches and the collecting ditches are shown, also the construction of solid bunds for the colmata and more modest ones for the colmatelle.

Plate 17 is reproduced from a photograph taken of the farm of the Agricultural School of Macerata, and represents the disposition of the colmatelle along the circulating ditches " a spina."

Plate 16 represents in fact the hilly fold of Plate 15 after the work of colmata has been finished.

(42) A particular example is now given, and the land chosen is that represented in Plate 19. The contours, shown at 3·6 metres apart, instead of 1 metre to avoid confusing the plan, will give a full and clear idea of the surface. On the top of the hill is the farm house.

It will be noticed that on the east and west sides there are deep ravines in which all the water from the farm is collected.

(43) This land is worked on the system of " ritto-chino," as represented in Plates 20 and 21.

The earth is furrowed in the sense of its greatest slope and divided into ridges (porche) 2 to 5 metres wide, *vide* marginal sketch.

The water much sub-divided runs along the little ditches separating the various ridges, but when these are of considerable length the water acquires an excessive velocity and causes erosion.

The furrows tend to diminish the damage which will evidently result from this erosion, and to discharge the water in the direction indicated by the arrows.

The damage caused by this system of working is evident. The land is placed under cultivation, but owing to its irregularity a good part of the surface cannot be cultivated and its productivity is very low, owing to the washing it undergoes from the water, so that the substitution of another system on the lines which will now be described will be an economy.

(44) Given a very irregular tract of land, the tracing of a sytemization a spina cannot be carried out without, at the same time, solving the important problem of the regularization of the surface by means of " Colmata di Monte."

The physical mechanical nature of the land lends itself quite well for the execution of such work.

(45) It has been said elsewhere that the construction of the basins of colmata is the first and also the more interesting step in the prosecution of the systemization.

In the present case the lie of the land is such as to permit and render relatively easy the work of colmata.

The disposition of the land placed under colmata is represented in Plate 22.

There are two principal systems of silt basins : the waters are collected in them, and their course is regulated by means of channels which guide them to erode the higher and nearer parts.

The location of these channels is liable to be changed from year to year. Other little basins (colmatelle) are made here and there along the circulating ditches in the slight depressions. These colmatelle communicate with one another and with the principal basins by means of a series of little silting ditches.

(46) The earth necessary for the colmata will be furnished by the erosion of the more elevated parts of the soil, and these are shown in good relief by the contour : also to a large extent by the turbid water of the ditch A. B., which carries the water which drains off the lands above.

In a sufficiently elevated depression in the hill, and in such a position to allow of its collecting a copious supply of the rainfall, the little lake is made whose function has already been explained.

The earth used in the construction of the banks will be that coming from the excavation of the silting ditches, and eventually that brought down from the nearest prominences.

The alignment of the systemization a spina when the work is completed is shown in Plate 23.

Figure 32 and the section show the arrangement of the land when the work is completed. It should be noted that the sections and plans are drawn to different scales in order to show the differences of level more clearly.

(47) The reasons why some authorities do not consider the systemization a spina to afford cultivation all the character necessary to render it rational must now be stated. They are as follows :—

(*a*) The carrying away of the earthy matter will be but little diminished by this system.

(*b*) The water, running off one of the strips of land (lenza), can erode and carry away a good deal of earthy matter before reaching the ditch made to receive it.

This earthy matter is collected in the ditches to be used for laying at the roots of the trees, but in the period of specially heavy rainfall a part of it, and precisely the better part, is in some way inevitably lost.

In the systemization a spina, the lines of trees can be put above or below the ditches. If they are placed above the ditch, in addition to its being difficult to lay the earth at their roots, the trees are exposed to excessive drought in the summer time : if below it is not so difficult, but the slope of a single strip is gradually increased, because it is raised on the up-stream side and subject to continuous erosion on the down-stream side.

However, this last objection loses somewhat of its force when it is considered that the work of the plough annually reduces to some extent this raising and tends to establish some sort of equilibrium.

(48) One of the objects which any systemization must aim at is that of allowing the land to absorb a large part of the rain falling on it, in order to form a reservoir of moisture, as it were, for the dry season.

Whether this object is reached with the systemization a spina as described above is doubted by some.

The water still runs off the surface with too much velocity and the absorption of the rainfall cannot be much increased, especially when the land is somewhat compact.

It is only in the land in proximity to the collecting ditches that the absorption is increased, because the water runs in them with less velocity.

(49) In order to find a remedy for the above drawback, to carry out, that is to say, a rational system of agriculture, Cuppari counsels the adoption of the system of terracing the land.

(50) The systemization a spina from its nature is destined to be transitory for the reason that the cross-ploughing of the compartments tends to gradually diminish the slope of the land until at last true and proper banks are formed.

The systemization a spina is transitory.

(51) It is not every one, however, who takes it into his head to follow this plan.

Some oppose the formation of terraces and do so in this way : after the land has been ploughed the earth of the first furrow of the strip *a* is shovelled into the void left by the last furrow of the strip *b*, *vide* marginal sketch.

Thus, although the slope of the hill is maintained unchanged, the surface nevertheless is lowered from always losing earth on the up-stream side—this is a serious fact and not without harmful consequences.

(52) Conti, however, says that those who like himself have learned to recognize how very necessary it is to decrease the slope in order to preserve the land in the best condition possible, must consider the systemization a spina to be altogether transitory and leading to the gradual terracing of the slopes.

Even if this is not done it will nevertheless be recognised, he says, to be of much utility and to possess many advantages.

(53) But even if it is understood that this may follow, this system is still opposed by some.

Terraces reduce the productive surface too much.

This is true, but if one considers that the production on a horizontal plane is greater than on an inclined plane of the same area, and if the grass on the slope is taken into account, one sees how little loss there is in this respect.

(54) Terraces are found fault with because they leave the soil too much exposed to drought on account of the evaporation from the slopes.

(55) In regard to this Conti says, " we will consider with Cuppari the following two facts :—

First, even if the slopes of the terraces evaporate more in summer, they have accumulated in the spring, a great reservoir of moisture in the subsoil : secondly, that in the case of inclined surfaces specially, the superficial roots have force, depth and direction different in comparison to the lower roots."

(56) It is thought that the grassy slopes will immediately grow weeds on ceasing to yield any other product, and that they will fall into ruin by the continual scraping away of the base and by the piling up of the earth on their crests.

This objection, however, while it has some force in the case of walled terraces, is quite erroneous seeing that annual maintenance and repairs are required as much in the case of terraces as in the case of the systemization a spina, if the work is not to be compromised.

(57) The objection, which can more fairly be urged against the system of terracing, is the expenditure involved, which renders it only economically possible in those places where especially intense cultivation is followed.

Conti agrees with Cuppari that enterprising cultivation in the hills must be preceded by a system of terraces.

The system of directly terracing the land is hence only possible in rare cases ; but it is not this kind of terracing that is here being treated of, and one wishes to think of a more economical, though not so rapid a method, of arriving at the same result. Such a means, Conti considers, to be at one's disposal if one thinks that by the system of cross working the systemization a spina can be gradually transformed into a true and proper system of terraces.

(58) When the slope of the soil does not exceed 10 or even 12 per cent. on lands sufficiently permeable, the systemization a spina can solve many of the inconveniences. In such cases it can be maintained as such, and in order to do so the method as described in paragraph 51, must be followed.

(59) When, on the other hand, the slope of the land exceeds the above limits after the systemization " a spina " has been completed, one must try to reduce the excessive slope by means of gradually terracing with the annual work of the plough. This ploughing is hence destined sooner or later to accomplish the terracing in the most economical manner possible : nor is it clear why one should not try to reduce the slope from the moment that it seems possible, in order to obtain in the hills all the advantages in the plains by excluding the disadvantages which the latter present.

Conti sums up by saying if the systemization a spina be considered transitory, the inconveniences which it can give place to are destined to gradually disappear as it approximates, owing to the annual agricultural operations, more and more to a perfect system of terraces.

(60) The following description of the Colmata di Monte is taken from Marquis Luigi Ridolfi's work on cultivation in the hills.

(61) The plan, *vide* Plate 24, represents a valley on his estate at Mileto.

The difference of level between the higher and lower portion of the valley is 140 metres and the top is 190 metres above sea-level. Contours are shown at every 5 metres where the valley is steep, and at every 25 metres where less so.

A farm road runs along the southern crest of the basin and on it are shown the contour heights. Another road takes off at A, crosses the valley on the bank $a\,a'$ and rises again to A' along a spur of the hills which divides the basin into two.

Other less extensive prominences along the ridge $C_1\ C_2\ C_3$ separate two great central depressions which may be called ravines. These ravines have lost a large part of their forbidding aspect due to the erosion of the soil, so that they are now more or less level land.

(62) At the outset one must consider how to lay out a system of ditches and dispose the various slopes in a proper manner ; and this must be done, not only where the work is likely to succeed best, but for the whole surface.

One must proceed to raise the bottom levels and to depress the prominence by utilizing the drainage water to erode the latter to fill up the former.

(63) The work was commenced with the road bank $a\,a'$, and this in the course of time was repeatedly raised and, as a consequence, also lengthened.

The rainfall over the whole basin above this bank and between the two roads $a'\,A'$ and $A\,A''$ was impounded at the back of this bank, up to a height determined by the overflow weir established on one of the flanks ; this weir was shifted from time to time according to the deposit of the silt in the basin above.

(64) Where the bank had been raised sufficiently, and so much so that it was not likely to make the lands below cold, a second bank $b\,b'$ parallel to the first was then constructed to form a new silting basin. This bank was similarly raised and prolonged from time to time and provided with an overflow weir : the plan shows it on the right flank where it was actually made, and where it was found convenient to allow it to remain.

(65) The water which flows over this second weir is, by means of suitable ditches turned and distributed among those parallel ditches which in the meantime have been made to divide the fields in the first silted-up basin. The annual clearance of these ditches tends to the gradual raising of these same fields which are by now large enough for cultivation.

The water from these field ditches runs into a collecting ditch, which is given an angular course along the other side of the valley.

(66) The water in the collecting ditch runs just above the bank $a\ a'$, which it crosses by a masonry bridge together with the water which comes down the ditch $b'\ a'$.

(67) Here, in leaving off to follow and describe the subsequent proceedings with the colmata above, it may be explained that the same system was followed above the bank $b\ b'$ as below it.

(68) When the colmata was sufficiently advanced above the bank $b\ b'$, a third bank $C\ C_{,}\ C_{,,}$ was made.

This was given a kink in order to close at right angles each of the ravines into which the valley is divided.

The same procedure as already described was followed in this case too.

The plan shows the overflow weir finally established at C'', but in order that the water should not run directly and therefore rapidly towards the overflow weir of the bank $b\ b'$ at b' it is diverted across the valley and then follows an angular course along the base of the hill on that side.

(69) The agricultural ditches of the second silting basin have their heads in this ditch and divide among themselves the water running in it, which is once more turned into a collecting ditch which leads to b' and from this point it is carried by the ditch $b'\ a'$ to be again divided between the agricultural ditches of the first silting basin.

(70) In this way the progressive raising of these two basins proceeds by means of the annual clearance of these agricultural ditches, the silt from which is thrown on the down-stream edge of each ditch and then spread over the fields at the time that are ploughed over.

(71) Above the bund $C\ C_{1}\ C_{11}$ are two hollows which are now closed by equidistant and parallel banks; these are gradually raised as the basins above them get silted up.

(72) Silty water is conducted to these basins by various channels opened on the sides of the hills when the agricultural work in the field is going on.

In aligning such channels one has to strive at one and the same time to preserve any sowing that has been done, and to direct the water with more or less velocity, according to the inclination of the various tracts, to carry earth to those parts where it will serve to improve the lie of the land. When, owing to successive working the prominences are levelled down, the drainage water is diverted along another course.

(73) On account of the rapid rise of the hill and the bottom of the ravines above the bank $C\ C_{,}\ C_{,,}$ extended tracts of colmata (to be divided into sloping fields) cannot be formed. It will also be a long time before the joint work of agricultural labour and colmata in depressing the prominences or crests $C_{1}\ C_{2}\ C_{3}\ C_{4}$ and in raising the bottom of the ravines, will admit of fields being formed on the slopes of the hills by means of angularly aligned ditches (systemization a spina). These ditches have been shown on the plan on the left of the road $a'\ A'$ in a tentative manner for the purpose of showing how they may probably be aligned, although it may be found necessary to alter them in practice afterwards.

(74) Continuing now the description of the proceedings which are always in action. In spite of the long meanderings and the partial stagnation of the water in the above described colmata of the hills, it always carries off a certain amount of matter which it does not deposit, unless brought to a state of absolute rest. This then is the advantage of never desisting from trying, in the lower lying valleys also, to decrease to the utmost the velocity of the water by holding up as much of it as possible in large and ample ditches, provided that this proceeding does not tend to render the land cold.

(75) The water which at the time of rain is not held up in the basin and in the silting ditches above the bank $a\ a'$ crosses the latter by a little bridge left open on its flank, and then is turned into a ditch which runs below the same bank, and then under the road which, on turning to the right, separates the valley from the hill above.

(76) This ditch on the plan appears to stop at the point E. This is because if it were carried on, it would have too great a slope as the line of levels show. The water, however, contained in the ditch is divided up among the numerous agricultural ditches and is collected again on the opposite side, reuniting with the water which is separately sent down along the boundary of the wood called Commune, from the other valley.

(77) In these cross-ditches, which have a gentle slope, the velocity of the water slackens and the water is partially held up in them by means of little bunds over the tops of which only the water runs into the collecting ditch.

Thus in the course of years a considerable deposit of silt takes place. This is dug out every summer and thrown on the down-stream of each ditch along which the lines of vines and poplars are placed.

(78) Referring to the plan and following the contour of 55 metres, it can be seen how the said collecting ditch comes to be carried higher and higher up on the side of the valley, when, owing to the gradual raising of the bottom of the valley and the consequent lengthening of the fields and cross-ditches, it can no longer fulfil its office : the same cross-ditch can always be commanded by the discharge ditch of the higher colmata.

(79) It can be quite well foreseen that the said discharge ditch may become one day a collecting ditch if the course of the water in the cross-ditches of the valley is inverted, when the water from the colmata above is turned somewhat higher up into a new silting ditch (colmatore) to be opened up on the opposite side. Into this latter the water from above a new road bank will have to be discharged, this bank being constructed between *a' A'* and the above mentioned wood, with its crest about 60 metres above sea-level, thus closing the valley, in the bottom of which is the ravine which collects the water, and so forming a new silting basin.

(80) It must be borne in mind, with reference to the possibility of this last, that the proposed procedure here treated of can only be roughly sketched out and that, in order to put it into practice, it is necessary to foresee and prepare for a long time beforehand the course to be followed. For the portion already undertaken, the actual position of the silting ditches secures that they will perform their functions properly for a sufficiently long space of time : this work of colmata divided, as it is, among a considerable number of ditches, must be necessarily slow, especially as this part of the valley is no small one.

(81) It must now be explained how the same work is prosecuted lower down.

The lower contour lines show that the bottom of the non-wooded valley may be naturally higher on the left side than on the right in regard to its longitudinal slope.

If, however, the water brought to point *E* of the collecting ditch (of which mention has been made above) should have continued its course on the same side of the valley, it would have risen but little in the cross-ditches of the fields and, hence, it would not have been possible to have used them for forming fresh deposits in them.

For this reason it was considered expedient to turn the said collecting ditch from *E* across the valley in order to carry it past the opposite sides of the fields. In this way the water running in it could be divided in the usual way between different cross-field ditches, which were led away from it, and these latter, as usual, will all find an outlet in another collecting ditch opened in continuation of the one above. On the plan the lower ditch appears to start afresh at *E*, but in reality the deviation of the course of the water is here obtained by means of a solid bund, or weir, over which the water flows on occasion of extraordinarily copious rainfall only.

The ditch, which has here become a silting ditch, is continued on the left side of the valley only up to *G :* at *G* it turns again across the valley, for which reason it does not join the water of the brook Fontaccia, which has been diverted under the wooded hill Tagliatella and brought to *H* in order to command with its water the cross-ditches of the valley which take off from it.

The two watercourses which collect all the water of the superior branches of the same valley traverse it a short distance apart, and unite as one, which henceforward, under the name of the brook of the Maremmana, keeps along the right side of the larger lower valley until this opens out in the plain of the River Elsa, into which it flows. All of the water, however, does not flow *directly* into the Elsa, because every cross-ditch takes off a portion of the water to be returned again lower down : in this way the water deposits its silt, which is annually dug out and then thrown or spread over the fields.

(82) One has an example of this in the lower tract, which is shown on the plan.

The cross-ditches which divide the lower portion of the valley into fields are seen to be commanded by the brook and, since the water in this tract will not be able to reach right up to the foot-path which separates the tract from the hill above, a collecting ditch *I K*, is opened somewhat lower down for the purpose of collecting the water and conducting it where necessary.

SECTION IV.

Conclusions to be drawn from the Italian Works and an examination as to how far they are applicable to India.

(1) The method pursued in Italy for the utilization of silt for the reclamation of swamps and marshes, which have been described in Section II of this Report, will not be unfamiliar to Irrigation Engineers in this country who have had to deal with silt traps.

(2) Silting operations in this country, however, have been for the most part directed to the strengthening of the banks of a canal where they happen to be in high embankment or in bad soil, and in order to avoid the digging of formidable borrow-pits, either inside or outside the canal banks.

A very economical and simple method known as *the system of internal silting* has been evolved which is now widely followed in the case of new canals and distributaries.

(3) The earliest attempts made with this object in these Provinces were on what is known as the *in-and-out system;* and although the results were successful, the operations were both protracted and costly, and would afford no guide as to the cost of the reclamation of a considerable area.

(4) It is only within the last few years that attempts in these Provinces have been made to utilize the silt carried in our canals for the sole purpose of reclamation of any considerable area.

These works are still in operation, but I hope to give in the appendix a note as to their probable cost, and what return they are likely to give on the estimated expenditure.

(5) The chief thing noticeable in regard to these reclamation works in Italy is the large scale on which they are carried out, and this is only possible where the physical conditions of the country are as favourable as they are in Italy, and where the rivers carry such an enormous volume of fertilizing silt.

Owing to these favourable conditions the engineering works are of a comparatively simple character. There, it is not a difficult matter to divert the turbid waters of the numerous torrents running down from the Appenines into the marshes and swamps, which are found in so many places near their mouths along the sea coast.

(6) Even where the whole torrent cannot be bodily turned into the marsh, a short diversion canal only, as a rule, is required, owing to the high slope of the alluvial plains between the foot of the hills and the sea. The soil, too, is of such a character as to admit of such canals being carried to the silting basins in high embankments without much fear of breaches, or without any percolation which might be harmful to the contiguous lands if a proper system of drains is provided.

(7) The fact that the canals can be safely carried across the country in high embankments, so that the bed of the canal where it enters the silting basin can be fixed at or but little below the level to which it is desirable to raise the land, is an enormous advantage to the efficient working of such a silt-carrying channel and does away with the necessity of any final levelling off by manual labour which adds so much to the cost.

(8) The uniformity of the surface, when the colmata is finished, is remarkable and leaves little or nothing to be desired. Lastly, the works necessary for getting rid of the water after it has deposited its silt, are of the simplest character owing to the close proximity of the sea and small difference in level.

(9) The engineering works required, therefore, are not of a very costly character, but whether the larger works of colmata have been financially successful, it is impossible to say, as many of these works have been in operation for years, and no separate figures are available for the expenditure on colmata alone, apart from the expenditure incurred on embankments, drainage, agricultural roads—all of which are included under the head of Bonificazioni.

(10) Sir Edward Buck in his report quotes figures which show how greatly the value of the land has been enhanced wherever colmata has been carried out.

The engineers, too, are of the opinion, and I see no reason to doubt it, that if such works could be commenced anew with the experience of the past, they would not only be very profitable but also be carried to completion in far less time. It must, however, be repeated that the Italian Government has embarked on these works or the sole object of getting rid of malaria, without regard to financial results.

(11) The amount of silt carried in suspension in the water of many of the torrents and rivers of Italy is enormous, as the following table shows :—

Name of torrent.	Proportion of silt to water by volume.	Percentage.
Esse	$\frac{1}{33}$	3
Foscana	$\frac{1}{20}$	5
Parce	$\frac{1}{33}$	3
Salcheto	$\frac{1}{20}$	5
Salarco	$\frac{1}{11}$	9

The above torrents are in Tuscany and the observations were carefully made by Signor Guili during flood time.

(12) The following table for the rivers visited during the course of this tour has been prepared from information supplied by the Engineers :—

Name of river.	Proportion of silt to water by volume.	Percentage.
Volturno	$\frac{1}{100}$	1
Ombrone	$\frac{1}{10}$	10·00
Cornia	$\frac{1}{15}$	6·66
Lamone	$\frac{1}{10}$	10·00

The figures in the two tables above may be considered as maxima. They show the enormous amount of denudation which is going on in the Apennine ranges, largely due to the disafforestation of the hills, the increase of cultivation and the geological character of the soil.

(13) The following table has been prepared from the data given in Mr. Buckley's "Irrigation Works of India" for the purpose of comparsion, and to afford some idea of the amount of silt in suspension in some of our Indian rivers :—

Name of river.	Proportion of dry silt to water by weight.	Remarks.
Indus	$\frac{1}{237}$	Mean during the flood season observed during the latter half of July and first-half of August.
Nile	$\frac{1}{670}$	During August when in flood.
Bengal rivers	$\frac{1}{1642}$	Mean of 234 experiments on rivers in Bengal at or near the surface.
Ganges	$\frac{1}{760}$	Average of 4 samples taken in August and September near the head of the Ganges Canal.
Do.	$\frac{1}{82}$	27th August during the Gohna flood at Narora.
Do.	$\frac{1}{103}$	28th August, day after Gohna flood at Narora.
Do.	$\frac{1}{3048}$	14th October at Narora.
Sutlej	$\frac{1}{47}$ to $\frac{1}{89}$	These are maximum figures for experiments extending over 4 years near the head of the Sirhind Canal and were taken in July and August.
Sone	$\frac{1}{130}$ to $\frac{1}{177}$	These are maximum figures for experiments extending over 4 years near the head of the Sone Canal in the months of July and August.

The above figures show how small a proportion of silt our Indian rivers contain in comparison with the Italian rivers and torrents. On the other hand the flood season is probably longer in India as in Italy, there may be only 10 or 12 floods during the season lasting some 2 or 3 days : the rivers are mostly of a torrential character and rise and fall very rapidly.

(14) The following statement, also from Mr. Buckley's work, shows the two chief constituents (clay and sand) of the silt in the waters of the Sutlej and Sone. It will be noted that the proportion of clay is much greater in the Sone river :—

Name of river.		Oz. of silt to 10 c. ft. of water.	Volume of silt to volume of water.	Percentage by weight.	
				Clay.	Sand.
Sutlej river.	Average of 30 samples June, 1895 ...	47·91	$\frac{1}{268}$	66·7	33·3
	Ditto 18 ,, July 1895 ...	18·79	$\frac{1}{531}$	71·3	28·7
	Ditto 26 ,, August 1895 ...	50·23	$\frac{1}{199}$	79·9	20·1
	Ditto 11 ,, Sept. 1895 ...	4·88	$\frac{1}{2037}$	76·6	23·4
	Average for June, July and August ...	38·97	$\frac{1}{256}$	72·6	27·4
Sone river.	Average of 12 samples June, 1898 ...	15·4	$\frac{1}{648}$	99·6	0·4
	Ditto 23 ,, July 1898 ...	32·0	$\frac{1}{312}$	90·6	9·4
	Ditto 26 ,, August 1898 ...	23·6	$\frac{1}{423}$	83·4	16·6
	Ditto 22 ,, Sept. 1898 ...	7·1	$\frac{1}{1406}$	95·4	4·6
	Average for June, July and August ...	23·7	$\frac{1}{421}$	91·2	8·

(15) In some experiments the writer made at Narora he found that the ordinary river sand of the Ganges, well pressed down and quite dry, weighed 90 lbs. per c. ft., and that the ordinary fine clayey silt of the Ganges, well pressed down and quite dry, weighed 80 lbs. per c. ft. Ordinary silt may be taken as a mean of the two, or 85 lbs. when dry and well pressed down, so that to obtain the ratio of volume of silt to volume of water, when the ratios are given by weight, we must increase those ratios in the proportion of 85 to 62·4.

(16) Few irrigation Engineers will deny that *wherever fertilizing silt can be found it would be a grave error not to carry it on to the fields*, if it be economically possible to do so.

The agriculturist, too, in many parts of India, is alive to the advantages of silt.

In Midnapur, where the rainfall is sometimes as much as 10 inches in 24 hours, in order to take advantage of the fertilizing silt in the canal water the cultivators draw off the rain-water as quickly as possible, in order to admit the former. Long experience has proved to them that they get better crops by irrigating with the silt-laden water of the river than from the rain water.

(17) It is, however, remarkable, and the matter is under investigation, that the cultivators in the canal-irrigated districts of these Provinces make little or no use of the silt which they clear from their guls, although this silt is, to all outward appearance, identical with that to be found in our silt-traps which bear the most luxuriant crops.

(18) Lieutenant, now Sir Colin Scott-Moncrieff, in his *Irrigation in Southern Europe*, states, that the price paid for the waters of the Po in Italy was three times the amount paid for those of the Doria Baltia, owing to the fertilizing nature of the silt contained in the waters of the former.

(19) He also refers to the marked difference between the meadows irrigated with the silt-bearing water of the Durance Canals in France as compared with those of the clear cold Sorgues, so much so, that cultivators prefer to pay for the former ten or twelve times the price asked for the latter.

(20) I do not, however, think that it has ever been sufficiently appreciated as to how much has been done in the past, and is now being done, in this respect, by our great Indian canals, which irrigate according to the last return some 20 millions of acres of land annually.

What, however, is the precise value to the land, we unfortunately have so far no sufficient data to show, but the cumulative benefits, continued as they are from year to year, must be very great.

The pores of the lighter and sandy classes of soil get filled and compacted by the infiltration of impalpable silt and are not only rendered more fertile, but require less water in the course of years.

(21) Dr. W. Leather has stated that the results of his experiments (though where these were made is not known) have led him to the conclusion that the amount of silt and its contents of nitrogen and phosphoric acid are but very small during the cold weather, and quite insufficient to replace the plant-food taken from the soil by a crop of wheat ; but, on the other hand, the silt carried on to the land during the monsoon period contains very material quantities of these plant-foods, which are probably fully sufficient to replenish the amount of plant-food taken from the land by the rice crop.

According to the analyses he has made, some 32 lbs. of nitrogen and 42 lbs. of phosphoric acid were supplied by canal silt during the monsoon, as against 8 and 10 lbs., respectively, during the cold weather.

(22) These figures point to the desirability of encouraging *kharif* irrigation by low rates, and seem to indicate that a season of drought, when irrigation is continuously in progress, may have some compensating advantages.

(23) I have made a rough calculation of the amount of silt deposited annually on the land in a year of average irrigation by the waters of the Ganges, Lower Ganges, Eastern Jumna and Agra Canals.

The amount would be sufficient to cover 14 square miles to the depth of 1 foot—no inconsiderable amount. This would be equal to an annual depth of deposit of $\frac{1}{2000}$ of a foot.

(24) It has been estimated, from certain facts connected with the foundations of the two Colossi seated on the plains of Thebes, in Egypt, that the Nile, which has nearly every year flooded this plain for something like 2,400 years to a depth of 3 or 4 feet, has raised it by 6 feet : this is at the rate of $\frac{1}{400}$ of a foot per annum.

(25) Now, with regard to the question which Sir Edward Buck has raised on page 15 of his report—

First "as to whether the silt of Indian rivers and canals specially in sub-Himalayan tracts can be profitably utilized ;" and secondly, "as to how far existing canals can be utilized for the distribution of fertile silt." I can only speak of that part of India with which I am well acquainted, *viz.*, the Jumna-Ganges Doab.

(26) As regards the canals in this tract, I have already shown that no inconsiderable volume of silt is annually deposited on irrigated lands, especially such as are irrigated during the flood season, although the film of deposit is almost infinitesimal.

The canals in this tract are generally working to nearly their full capacity when the earliest floods which are said to be the richest in fertilizing silt, occur, so that there is little or no scope at this season of the year for a further distribution of fertile silt.

To do so at a later period of the monsoon, when irrigation has slackened or entirely ceased, might lead to water-logging and its other attendant evils.

(27) With regard to the reclamation of inferior or worthless land through raising it with silt, as I have already stated, there are at the present time a few such schemes in operation and now that attention has been more particularly directed to the question it may be found possible to undertake more.

(28) The conditions are by no means favourable in this Doab for operating on Italian lines, as unless a tract of low-lying land happens to be in the vicinity of the canal (which is rare) a diversion canal would have to be constructed to carry the silt-laden water to the tract to be reclaimed, and generally somewhat expensive works to get rid of the clear water. In such cases the water would be lost to the canal and silting operations would be intermittent and prolonged, depending on the requirements of irrigation.

(29) In some favourably situated places the work of reclamation from other rivers, not drawn upon by our canals, might be found profitable ; but the preliminary investigation mentioned in Section 1, para. 20, would first have to be undertaken. Such works would, however, be local and limited in extent, for there is no doubt that our Indian rivers do not contain anything approaching the volume of silt to be found in the Italian rivers.

(30) Any large and extensive schemes for the utilization of silt for the reclamation and improvement of land in this part of India would not financially, in my opinion, pay, and could not therefore be undertaken.

(31) To carry out a scheme for the fertilisation of land on a large scale it would be necessary to construct canals similar to our irrigation canals, and a system of basins such as are to be found in Egypt.

The conditions in this part of India are not so favourable as in the Valley of the Nile, where the cost of basin irrigation, according to Mr. R. B. Buckley, has been between Rs. 45 to Rs. 60 per acre on an area of two million acres.

(32) Basin irrigation, too, means that only one crop per annum can be grown, and it is therefore not so profitable as perennial irrigation with which, in Egypt, two crops, at least, can be grown : hence, the tendency in Egypt at the present time is to construct more storage works to enable the basin irrigation to be converted into perennial irrigation.

(33) Colmatage has been carried out on a considerable extent in Southern France, but, even under the most favourable conditions, the cost is high.

(34) The following account is taken from "*Irrigation in South Europe*" as it has been referred to in Sir Edward Buck's Report :—

"M. Thomas having a property composed of gravel and stones and only fit for grass crops, laid some of it out in terraces, and obtained the use of 14 cusecs of water from the Crillon Canal, which he turned over it for the four winter months of every year. After three years, he found he had covered an area of 22·2 acres with a coat of the finest alluvial matter from 20 to 27 inches thick. The cost of the operation, including a water-rent of 16*s*., was just £7 per acre. The land, which before had been worth £19-8-6 per acre, was valued after this improvement at £113-7-0, and yielded 7 or 8 crops of wheat without requiring any further manure."

The Crillon Canal takes out of the Durance River which carries a volume of silt approaching that which is to be found in the Italian rivers.

(35) It is quite possible that in some parts of India, particularly towards the sea coast, where the physical conditions may approximate more closely to those found in Italy and where there may be more fertilizing silt in the waters of the rivers it may be found practicable to carry out large reclamation works, but such works in these Provinces are not in my opinion practicable on any extensive scale.

It would be quite out of the question here to carry the silting channels in high embankments as in Italy, on account of the inferiority of the soil and risk of interference with spring level. This restriction would add largely to the cost of silting operations, as it means that a good deal of the silt has to be lifted by manual labour.

(36) Thirdly, as to "whether notoriously unhealthy tracts such as the Tarai can be treated on Italian methods for checking malaria." I may claim to have an intimate knowledge of the Kumaun Tarai, having served in that tract for 5 years, and do not think that in this Tarai they can for the following reasons :—

The unhealthiness of the Tarai is due to the superabundance of water to be found everywhere, affording most favourable breeding-grounds for the anopheles

mosquito. The stoney talus at the foot of the hills, known as the Bhabar, absorbs the rainfall and a good deal of the water of its streams, and this water re-appears at a lower level in the form of springs.

It would not be possible to get rid of these springs even if a layer of silt could be placed over them.

(37) This Tarai is far less unhealthy than it was formerly, when it was the custom to dam the river and streams for the purposes of irrigation with large earthen bunds, which formed large and pestilential swamps behind them. A graphic description of the condition of the Tarai before these bunds were removed is given in a book on "Irrigation in the Tarai" by Captain W. Jones, R.E., the pioneer Irrigation Engineer in this part of the country.

The policy of removing all bunds and substituting masonry regulators has been steadily pursued since 1890, when an engineer of the Irrigation Department was first appointed to the Tarai and Bhabar Estates.

(38) The Tarai has a high slope and drainage works have in some places been carried out, but it is practically impossible to keep any drains which take out of these spring-fed swamps in an efficient condition, owing to the dense growth of vegetation which again springs up in their channels immediately it has been cut down.

(39) I have no doubt that the Tarai would be healthier without rice irrigation, but, on the other hand, it is only possible to induce cultivators to face the unhealthiness of the Tarai because some of the finest kinds of rice, which are extremely profitable, can be grown there.

(40) Since the discovery of the malarial parasite by Laveran in 1880 increased attention has been paid to the mitigation of malaria in Italy.

Recent researches there have proved that the larva of the anopheles mosquito live near the foci of the watercourses; that water which is more adapted and more favourable to the life of the larva is clear, limpid stagnant water at an almost constant temperature issuing from the subsoil or springs.

In such waters a great growth of water plants is to be found, especially of the filamentous kind. This is especially favourable to the life of the mosquito, as is also the shade of trees in the vicinity of these pools or springs.

(41) Now these are precisely the conditions to be found in the Tarai and Bhabar, and it is easy to understand why the country, in both the Tarai and Bhabar, becomes more and more unhealthy as one approaches the line of springs.

(42) In fact the Tharus and Bhoksas, who seem to become immune from fever provided they reach the age of puberty, are the only people who can live in their neighbourhood. The reason for this acquired immunity would be an interesting study for medical research.

(43) While on the subject of malaria I may mention that all houses in the malarious districts in Italy which are occupied by Government officials of any degree are provided with fine gauze netting protections to all doors and windows.

(44) I may also add, in this same connection, that the Italian Government is now taking measures to fill up or drain borrow-pits along the lines of railways, roads and canals, since they are found to afford favourable breeding-grounds for the mosquito.

(45) This is certainly a matter which might receive some attention in this country.

Railways are great offenders in this respect and roads in a less degree: canals are happily in a position, as a rule, to furnish earth for their banks from their excavation, without the necessity for outside borrow-pits, and these too are now avoided by the method described in paragraph 2.

(46) In the plains of India it is no doubt necessary that roads and railways should be kept above country level and the earth for their embankments therefore must be taken from borrow-pits; but Government should fix some limit in the neighbourhood of cantonments, towns and villages within which no borrow-pits which are not provided with proper drains, should be allowed. I would suggest half a mile at least as the limit.

(47) Something too might be done to fill up or drain borrow-pits which have already been dug in the vicinity of habitations, and this would afford really useful work for famine labour, so difficult to arrange for, besides being an object-lesson to the people in sanitation.

(48) I must here express my profound admiration for the great work that Italy is carrying out for the purpose of improving the sanitary and economic condition of its people, a work which is giving the best results in extirpating the malarial mosquito, and which should be an object-lesson to the whole world.

(49) The expenditure incurred since the Act of 1900 was passed as stated in paragraph 14, has been Rs. 2,62,32,312 or Rs. 43,72,052 per year—a very considerable amount for the poorest and most heavily taxed country in Europe, and an amount, too, which the overburdened tax-payer ungrudingly bears.

(50) I believe I am correct in saying that the mortality from fever in India—most of which is malarial—is greater than that from all the other diseases together.

Even when not fatal in its effects, it saps the strength and energy of the people and is the cause of much human suffering. In a suggestive little book on malaria by W. H. Jones, M.A., recently published, it is shown, and not without good reason, that malaria must be considered as one of the many factors—and a not unimportant one—in the downfall of the Greek and Roman Empires.

No measures within reason should be neglected therefore to mitigate this scourge of tropical countries.

(51) The description of colmata in the hills may seem unduly lengthy, but this system is new to India, and I have therefore considered it advisable to explain it in considerable detail in order that any one may understand it. Admirable as the system is, and perfect in its results, as seen at Mileto, I have some doubts as to whether it is generally adaptable to this country.

In the first place, it must be remembered that the land in Italy is under intense cultivation, and, in addition to the cereals and other crops grown, the vine and other fruit trees are cultivated on the same land, so that a return of lira 200 to 250 per hectare (Rs. 48 to 60 per acre) is not uncommon, whilst the best irrigated land in this country will perhaps give a return of Rs. 10 to 20 only on the average.

It is a system that on a large scale could only be satisfactorily carried out under an enlightened landlord, and would not be suitable where there are likely to be conflicting interests. It can be economically carried out where there is estate labour available—as at Mileto.

(52) In the appendix is given a statement showing the rainfall in various parts of Italy.

It will be noticed that the annual rainfall is about the same as in these Provinces, but is more evenly distributed throughout the year. The season of heaviest rainfall in Italy being late autumn and early spring, the precipitation in the rainy season is therefore much heavier in India than it is in Italy, and the soil is generally less argillaceous and consequently more friable.

It would not therefore be possible to deal with large drainage areas without expensive arrangements in the way of weirs and falls.

After the system has been completed, but little, except the most careful supervision to put in the very necessary "stitch in time," is required: and here again divided interests might prove an obstacle.

Still the system is worth a trial, especially in the neighbourhood of large towns where intensive cultivation with irrigation and manure can be practised: and there are many places down in the ravines bordering on the Jumna where the drainage areas are not too large, and where the soil is fairly strong clay, in which land could be built up with a series of silting basins such as have been described.

(53) I am firmly convinced that the problem to be solved in many parts of these Provinces, and over a considerable part of India is not that of capturing the silt after it has found its way into our torrents or rivers, but *to prevent it getting there.*

(54) There are some in Italy, too, who think that the problem there has been attacked at the wrong end, and that if measures had been taken to stop erosion in the hills the necessity for the large embankments, which have to be raised from time to time and which are to be seen across the valley of the Po and many other parts of Italy as a menace to the surrounding country, would not have been so great.

The formation of the unhealthy swamps and marshes along the sea coast is in a large measure due to the action of the sea on the waters of the rivers, so heavily charged with silt from the denudation of the hills.

I have no doubt they are right and that this would have been theoretically the correct solution of the problem in Italy, but conditions had reached such a pitch that it was not economically possible.

Much can be done, however, to stop erosion and mitigate its evil results and this fact is now becoming appreciated in Italy, especially as such work as is to be seen at Mileto has been financially most successful.

(55) I have recently been inspecting some of the country which has been reported to be suffering from erosion in the neighbourhood of the Jumna, and I have formed the opinion that the most suitable method here for mitigating the effects of erosion and for conserving moisture in the soil is the method of field-to-field embankments and terracing. It is a fact, which unfortunately is only too patent in this season of drought, that the most fertile of soils cannot bear crops unless there is sufficient moisture in the soil or there are artificial means of supplying it.

(56) In a valuable paper on "Protective Works in India" by Mr. H. Marsh, C.I.E., in the *Agricultural Journal of India* for October 1906, a paper worthy of the close attention of all who are interested in the agricultural improvement of India, the following quotation from Mr. Impey's Settlement Report of the Jhansi District

for 1893 on the immense value of field embankments is to be found: "Though not exactly a source of irrigation but rather a means of conserving the benefits derivable from rainfall, the system of field-to-field embankments, found especially in Moth and the north of Jhansi, may here be mentioned. *It can scarcely ever be said to have received the attention it deserves, for it is unquestionably of extreme value in protecting land against both erosion and kans, it recommends itself to the people themselves more than any other ambitious schemes as it has a direct fertilising effect.*"

* * * * * * *

"Field embanking is the simplest of all matters. A small earthen bund from 2 to 6 feet is thrown up along that side of a field which is crossed by the drainage from the field, flanks are added if necessary or, if the slope be very inconsiderable, the field may be inclosed by bunds on all four sides. One or two feet of water can in this way be kept up until after the end of the rains, and the land is thoroughly soaked before the winter sowings. In some parts of Moth and the north of Jhansi a series of these small bunds are found all down prolonged drainage slopes, and the land over which they have effect increases in darkness and in fertility every year.

* * * * * * *

"The advantages of the system are numerous. The people are willing to throw up the embankments and to take *takavi* for them. The rain-water is retained for the ground on which it falls instead of scouring into *nallas;* and as the *nallas* are deprived of their supplies they lose their velocity and power of cutting back into the good land above them.

The productive power of the land is increased and kans where it exists is drowned out."

This clearly explains the system and its advantages, and I endorse every word of it.

I would, however, add that where the soil is light and easily eroded as in the neighbourhood of the Jumna ravines in many districts, after the field bunds have been constructed up the drainage lines the fields should be brought to a level surface, so that the rainfall may be readily absorbed by the whole surface of the field and not concentrated towards the lowest part, where it often breaches the bunds owing to the poorness of the soil or has to be let out by the cultivator by a cut to enable him to cultivate this portion of the field: which cut, from carelessness, is often not repaired before the next rainy season.

(57) In this particular part (pargana Shikohabad) and many other similar tracts the cultivators thoroughly understand the system and have adopted it to their advantage, but chiefly in those cases where erosion is immediately imminent. The system has not been sufficiently extended, nor has it been carried far enough up the drainage lines, with the result that too much water comes down from above and their well-meant efforts are frequently wrecked.

The motto to be adopted in dealing with drainage causing erosion is "*Divide et impera,*" and this is one of the main principles underlying the successful example of Colmata di Monte at Mileto.

(58) To quote again from Mr. Marsh's paper—"Where an embankment is made which affects the interest of several individuals, but is too small for State management, difficulties are sure to arise about its maintenance. One man wants to cut the bank of his submerged field so as to commence ploughing for the spring crop, whereas another wants to retain the water for his rice plants. Then, again, there is often trouble about injury to standing crops from the escaping water, whilst the necesary annual repair causes difficulty unless there is a strong headman to arrange these matters. Thus, although large embankments are of immense value, and particularly so where there is an enterprising village headman, yet *they do not have the same permanence as the small banks made by a cultivator round his own field.* The truth of this statement is rendered patent by the many neglected embankments found in Central India."

(59) I may add that large embankments for protective purposes are generally only suitable where the slope is gentle and a considerable area can be submerged, but where the slopes are rapid a system of field-to-field embankments is the only effective one; also that a few breaches in these field embankments do not materially injure its efficiency.

(60) Sir Edward Buck has submitted as one of the questions for consideration: "Whether schemes can be prepared for inclusion in famine relief programmes."

I can imagine no more useful famine works than a system of village relief works for the embanking and terracing of fields in tracts like those bordering on the Jumna, which are suffering from erosion.

It is these tracts where there is no canal irrigation and where, as a rule, the spring level, already very deep, is becoming deeper still, which have suffered whenever there has been insufficient rainfall and which are suffering at the present time.

Such work could be carried out by the headman of the village and should, of course, be subject to supervision by inspecting office.

No technical skill but commonsense, and a good eye for the country, are necessary to supervise the work, as the people themselves will be frequently found thoroughly conversant with the system and its advantages. It will be popular as the people will be quick to recognize that it will be of permanent value to their fields and because the work will be carried out in close proximity to their homes.

(61) In treating of the serious evils of erosion Mr. Marsh writes :—

" The loss thus incurred in the cultivated area is more serious than any damage caused by *reh* efflorescence in the Doab, as the latter is temporary and remediable in the course of time, but the former is almost irrecoverable and permanent, after it has once reached a certain stage. Under the circumstances the matter deserves the most grave and serious consideration of Government with the object of introducing measures for the prevention of further loss, if not for the restoration of part of the land destroyed by the causes described."

With this I am in entire agreement. For the tracts bordering on the Jumna ravines field bunds and terracing are the first measure, I consider, that should be undertaken, as their effect in diminishing the run-off from the surface of the land and in moderating, in consequence, the erosive power of the rainfall will be very considerable. Their effect will be further enhanced if the land is subjected to frequent ploughing during the period of the monsoon. The advantages of terracing the land in order to permit the soil to absorb the greater part of the rainfall falling on it, so that it may form, as it were, a reservoir of moisture against seasons of drought, and in order to prevent erosion and the carrying away of valuable earthy matter, are very widely recognised in Italy. And although the system of terracing has not been extensively adopted in that country on account of its expense, it is nevertheless recognized that for the treatment of cultivated land in the hills, it is the most perfect system that has yet been devised. However this may be in Italy, the system of field bunds and terracing in this country, with its heavier rainfall and more friable soil, cannot be considered to be complete solution of the difficult problem of the prevention of erosion, nor is it advocated as such.

The adoption of the system is strongly recommended, because in this country it is widely recognised as, at any rate, a partial solution of the problem, and because it is a system adapted to this country and is moreover economically possible. When the system has been thoroughly carried out in any tract of country, the flow in the ravines and *nallas* will certainly be diminished and the erosive power of the run-off will, in consequence, be moderated. It may then be possible to restore part of the land already injured by erosion and build up land in some of the ravines by means of a series of silting basins, such as have been described.

Such works, however, should not, in my opinion, be carried out by State agency, but either as village relief works during famine or by State aid in the way of *takavi*, or grants-in-aid.

It is essential for the permanent success of such works that the people should earn to appreciate its advantages and not look to the State for its up-keep.

(62) In conclusion, Italy, like India, is almost entirely dependent on agriculture for its prosperity, and a great deal is done by the Government there to foster agriculture in every way.

One of the means adopted is the occasional appointment of a peripatetic Commission to examine and report on the improvements carried out by proprietors on their estates in different parts of the country, and then to adjudicate the rewards which take the form of titles or medals.

Encouragement of this kind would, I think, have good results in this country.

Rainfall in various parts of Italy.

Town.	Spring.	Summer.	Autumn.	Winter.	Annual.
	Inches.	Inches.	Inches.	Inches.	Inches.
Turin ...	10·94	9·18	8·44	4·81	33·37
Milan ...	9·94	9·31	12·62	7·62	39·49
Venice ...	7·44	8·03	9·56	4·94	29·97
Bologna ...	6·68	5·20	8·50	5·18	25·56
Genoa ...	11·40	6·62	20·37	6·46	44·85
Florence ...	8·96	5·20	12·50	8·50	35·16
Rome ...	7·25	3·20	11·37	8·80	30·62
Ancona ...	6·0	4·90	9·40	6·68	26·98
Foggia ...	4·6	2·70	5·40	4·55	17·25
Naples ...	7·2	3·10	11·67	10·45	32·42

Maximum rainfall 1·5 to 2 inches per diem.

APPENDIX I.

The statement appended gives particulars regarding 3 reclamation works now in operation by means of the silt of canals in the United Provinces.

No. 1 has been nearly completed, but Nos. 2 and 3 have been in operation barely two years.

The cost of maintenance has been estimated and is therefore only approximate.

The rental is estimated from the rental of other silt-traps on the Lower Ganges Canal. These traps are irrigated from the canal; water-rates being charged in addition to rent.

A portion of the Gorhni reclaimed area has been let at a rental of Rs. 12 per acre, and another portion at Rs. 6-5 per acre—the mean rental being Rs. 9 per acre.

Considering the favourable situation of the silt-traps on the outside of the canal banks, and that the only works necessary were a marginal embankment with outside drain and an inlet and outlet from and into the canal, the estimated return does not augur well for the financial success of works constructed solely for reclamation purposes.

APPENDIX II.

Since writing my report I have had an opportunity of inspecting the reclamation works carried out by Babu Lachman Pershad near the Agricultural Farm, Cawnpore, which has been referred to in Sir Edward Buck's report.

The reclamation consists in embanking and terracing the land along the sides of a ravine. This land had been somewhat cut up by the drainage down its slopes into the ravine.

The system is precisely what I have recommended in paragraphs 55 to 62, section IV, of my report.

The land is fairly good light soil and is well manured: it has the additional advantage of canal irrigation and of being close to the large city of Cawnpore.

The work has proved remunerative, according to Babu Lachman Pershad, and brings him in a return of Rs. 10 per acre.

APPENDIX I.

Particulars regarding some silt reclamation works on the Canals of the United Provinces.

Serial No.	Name of silt-trap.	Canal.	Area inside marginal banks.	Total area.	Capital cost, including Canal Establishment and Tools and Plant.	Estimated cost of maintenance, including land rent.	Total estimated cost, column 6, *plus* column 7.	Estimated cost per acre including value of land.	Original value of land per acre.	Estimated annual rent after improvement.	Percentage on capital cost.	Estimated number of years improvement works in operation.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
			Acres.	Acres.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	
1	Gorhni ...	Eastern Jumna	157	191	17,713	* 9,191	26,874	171	7·3	9	5·3	6	The land was originally *usar* and the whole volume of the Eastern Jumna Canal was diverted through the trap.
2	Piyaoli ...	Lower Ganges...	195	236	14,317	15,683	30,000	153	52·9	9	6·0	4	The land was originally swampy and injured by percolation from the Lower Ganges Canal.
3	Harnaut ...	Ditto ...	400	463	†35,792	9,208	45,000	112	50	9	8·0	6	The land was originally swampy. It is intended to turn the whole volume of the canal through this trap.

* Includes 6 years' rental of 34 acres at Rs. 41 per annum.

† One hundred and ninety-two acres of land were given free by the zamindars on remission of land revenue (Rs. 163 per annum) on condition that the land should be restored to them after improvement; for purposes of comparison, the value of this land, at Rs. 50 per acre, has been added to the Capital cost.

APPENDIX III.

Since writing my report I have been able to refer to the report of the Indian Irrigation Commission from which the following abstract has been made with reference to the value of field embankments, *vide* paragraphs 152 and 153, Part I, and also in various paras, of Part II.

The conclusions of this Commission will add much weight to what I have said in paragraphs 55—62, section IV of my report.

" 152. *Field embankments.*—Excepting wells, there is perhaps no class of land improvement which is more extensively employed or more useful than those which we have included under the generic term ' field-embankment,' which comprises the following two classes of works :—

(i) Embankments proper, known as bands or bandh is in the Central Provinces, bands in the Punjab and United Provinces, ahars in Bengal, bandhs in Gujrat, and *tals* in the Bombay Deccan. In broken country these works consist of dams across ravines or the beds of small streams and watercourses ; and, in flatter country, of areas embanked on one, two, three, or even four sides, the banks being of widely varying height and dimensions, from the low bank which encloses a rice field to the high and long embankments which enclose many acres of wheat in the Central Provinces. In these latter Provinces and in Bundelkhand (United Provinces) field embankments are found to be of special value in eradicating the noxious weed-grass known as kans, which succumbs to the complete and continuous flooding given by water held up within the embankments.

(ii) The terracing and levelling of sloping lands, with the object of preventing erosion of the soil and conserving moisture in it.

153. Generally no hard-and-fast line can be drawn between the two classes of works, as the damming of a dry watercourse or drainage depression results in the accumulation of silt and soil till the terrace is formed ; and a succession of terraces if often formed by a series of bands. By means of these works many acres of lane have been rendered fit for cultivation, and capable of withstanding the effects of drought, in most unpromising tracts of country, such as the barren uplands of the Bombay Deccan and Central India. In more fertile tracts, also, they render possible the cultivation in the *rabi* season, after the close of the monsoon, of the more valuable wheat crop in place of the less valuable millets and other monsoon crops. In South Bihar (Gaya, Patna, Shahabad), Chota Nagpur and elsewhere in Bengal, and in the Mirzapur District of the United Provinces, they secure the rice crop against the vicissitudes of ill-distributed rainfall. In hilly situations cultivation is generally impossible without terracing on an extensive scale, and " budding " occurs extensively in most submontane tracts. Ravine lands occur mostly near the banks of the large rivers traversing the great alluvial Gangetic plains. An excellent example of reclamation of such land is to be found on the Government Dairy Farm at Allahabad. But with regard to the immediate purposes of our inquiry, the main value of the embankment consists in the prevention of the escape of rain-water until the soil has been thoroughly saturated, in the permanent storage of moisture, and on the consequent raising of the sub-soil water-level to the benefit of well-irrigation in the vicinity. In some cases, as in the Central Provinces, the size of these embankments might be sufficient to justify their occasional construction by Government in ordinary years. But in the great majority of instances the work had best be left to private enterprise, for which it is peculiarly well suited. A good deal of money has been advanced for this purpose in the Bombay Presidency both in ordinary years and in years of famine. Substantial sums were given also during the famines in the Central Provinces. These embankments have also been made with considerable success as relief works in the State of Gwalior, where we saw several satisfactory instances of land reclaimed or in the process of being reclaimed by their means. Relief was also employed on them in Bundelkhand, in the Central Provinces and in the Bundelkhand States. They are likely to be useful in many tracts of black soil where direct irrigation would not be suitable. In the various Provincial Chapters we have recommended that strong encouragement should be given in ordinary years to the construction of these works, by liberal *takavi* advances, and by free grants in tracts exposed to famine ; and that in districts where their construction is likely to be of use, famine labour should be extensively employed on them."

APPENDIX IV.

FORESTS AND RUN-OFF (ENGINEERING RECORD, SEPTEMBER 7TH, 1907.)

It is matter of dispute whether the removal of forests always effects the amount of run-off from water-sheds, for records of certain European districts indicate that

deforestation has not been followed by increased floods and erosion of the soil. In examining the subject in detail, however, it has been observed repeatedly that where the removal of the forests has been followed by agricultural work which opens up the pores of the soil, assuming the latter to be somewhat coarse-grained, erosion may not be materially affected. This relation of forests and agriculture to run-off and soil erosion is pointed out in an exhaustive bulletin on the Potomac River basin recently issued by the U. S. Geological Survey, from which the following notes are taken.

If the rainfall is all absorbed, as by a coarse, sandy soil, there is no run-off and no erosion. As the soil becomes finer in texture, more compact and correspondingly less pervious, the rain is not absorbed as fast as it falls. The impact of the rain drops loosen the fine particles of soil, and unless absorption takes place the drops gather into small streams and rivulets, transporting with them, by a system of natural elutriation, the finest particles of soil and leaving behind the larger and heavier grains. At first this is entirely due to the hydraulic action of the impinging rain drops, but no sooner do the rivulets gather power, either by the added volume of the water or by increased gradient, than they likewise begin cutting loose and transporting the soil.

The capacity of a stiff soil for water is, in practice, 35 to 50 per cent. of its volume, or for ordinary formed soils 4 to 5 inches of rainfall to the surface foot. In spite of this capacity, the greater part of a heavy shower will usually not be absorbed. The coarse structure of a sandy soil permits the rainfall to be absorbed as rapidly as it falls. In a clay soil, unless in a high state of tilth, the pores are similar and there is less open cellular communication between them, and absorption must largely take place through cracks, worm holes, and root holes, and, when there are few of these, absorption is largely retarded until the air can be expelled. In the extreme case, that of a raw clay soil with its surface puddled by a previous heavy rain, the result is, as King points out, " that when a heavy rain falls, the close structure and feeble granulation result in the surface pores of the soil becoming so quickly closed that the soil air has little opportunity to escape, and yet only so fast as it does escape, can rain enter the soil, and hence during heavy rains the water accumulates quickly and extensively upon the surface."

The greater portion of the tilled soils of the Potomac basin, especially of the lower part, are of heavy type and close texture, and the run-off from them indicates failure to absorb. But were they well granulated and in good tilth they, as well as the more permeable sandy soils, could really absorb, without undue accumulation of surface water, a much heavier rain than commonly falls at one time on the Potomac basin.

The porous condition or granulation of a heavy soil necessary to effect absorption is best procured by the addition of humus.

There is room for a large storage of storm water in farming soils, and more rational farming methods must ultimately lead to this. The effect of such storage would be reflected in a diminished run-off of flood water, especially of midsummer rains. Little of the water thus accumulated would normally pass off as seepage to spring and river flow. The improved growth of the crops would utilize such stored water and give a more constant and available amount of soil moisture.

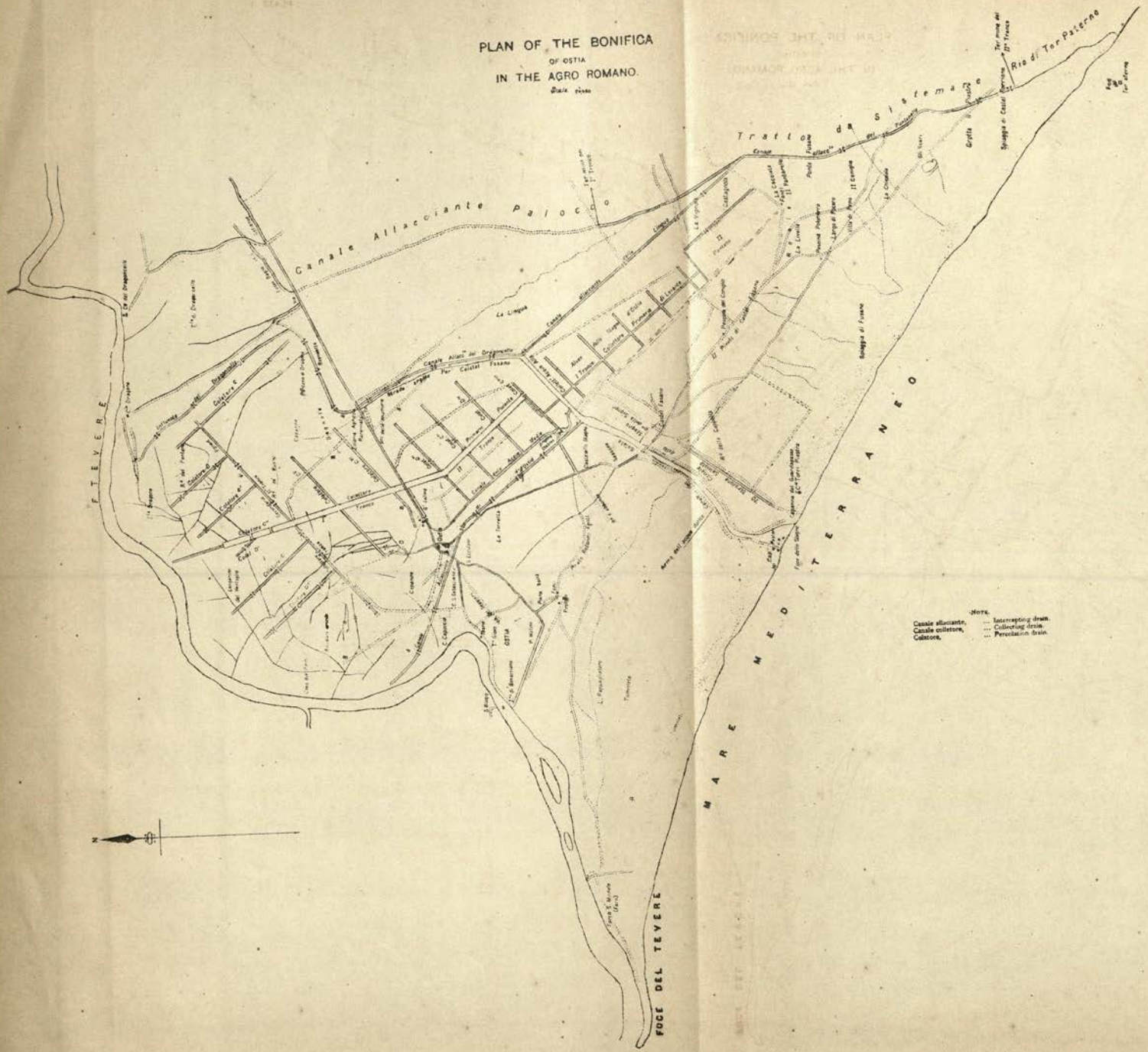
Any additional storage, either transient, tending to prolong or distribute a flood crest, or deep-seated, tending to increase the amount of the dry-season flow, can be secured only in the forest soil, except in sandy phases, takes place very largely through the medium of humus. The amount of water which is actually retained by a thin humus is small ; in fact, a thin humus is usually far more litter than humus and has a very low retentive capacity ; but the chief function of humus, except where it has accumulated to a great depth are (1) to maintain the volume and depth of the soil by preventing erosion, (2) to secure the porosity of the soil, (3) to promote the absorption of rainfall by the soil in retarding the run-off of heavy showers until the water can be absorbed, as the air is gradually expelled from the soil, (4) to act as a mulch and lessen the evaporation of soil moisture.

On coarse, deep sands of low gradient the office of humus is at a minimum. There is no surface flow of storm water and no soil transportation ; evaporation of soil moisture is low both from the surface of the soil and from transpiration by the xerophytic flora, and the larger part of the rainfall passes as percolation. With an increase in the clay component greater radient, and a decrease in soil depth, humus becomes more essential in supplementing the water-absorbing and water-carrying capacity of the soil, its function in this respect attaining a maximum on heavy, shallow clays of mountain slopes.

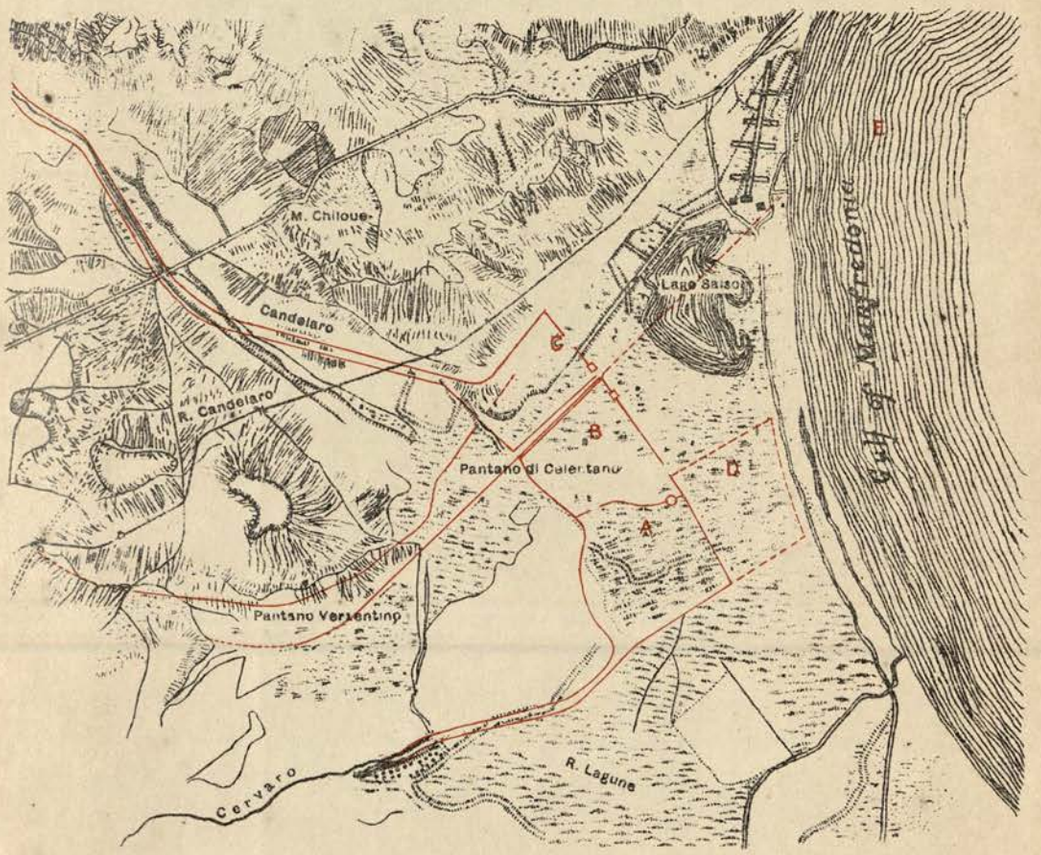
Where the humus is thick, however, it possesses a high storage capacity. While there is some doubt in regard to the exact amount of water humus is capable of holding, the quantity is relatively large. The lowest estimates by Ebermayer place it at considerably more than its own weight, and Wiley's investigations of Florida mucks give it about the same capacity ; while Wollney places it at about 4 times its weight, and Henry's laboratory experiments tend to confirm Wollney's

PLATE 1

PLAN OF THE BONIFICA
OF OSTIA
IN THE AGRO ROMANO.



GENERAL PLAN
OF
BONIFICA OF MANFREDONIA



REFERENCES.

	Area.
A. First silt basin of the Cervaro in operation	1,310 acres.
B. Second " " under construction	1,225 "
C. First " of the Candelaro in operation	1,297 "
D. Third " of the Cervaro projected	1,125
E. Sipontine Marsh drained by pumping	900
Marginal bunds of basin	
Overflow Weir	
Outlet	
River embankments	

CERVALLO TORRENT RECLAMATION WORKS.

SILT BASIN No. 1.

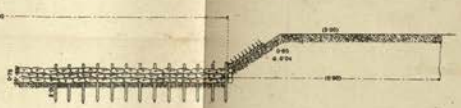
PLAN OF OVERFLOW WEIR.

Note.—Dimensions in metres.

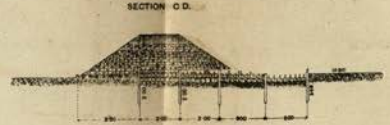
PLATE 3.

HALF ELEVATION.

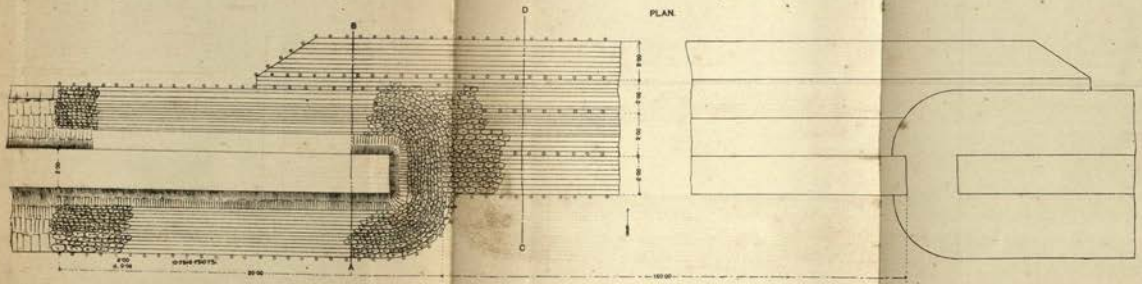
HALF LONGITUDINAL SECTION.



SECTION C D.



PLAN.

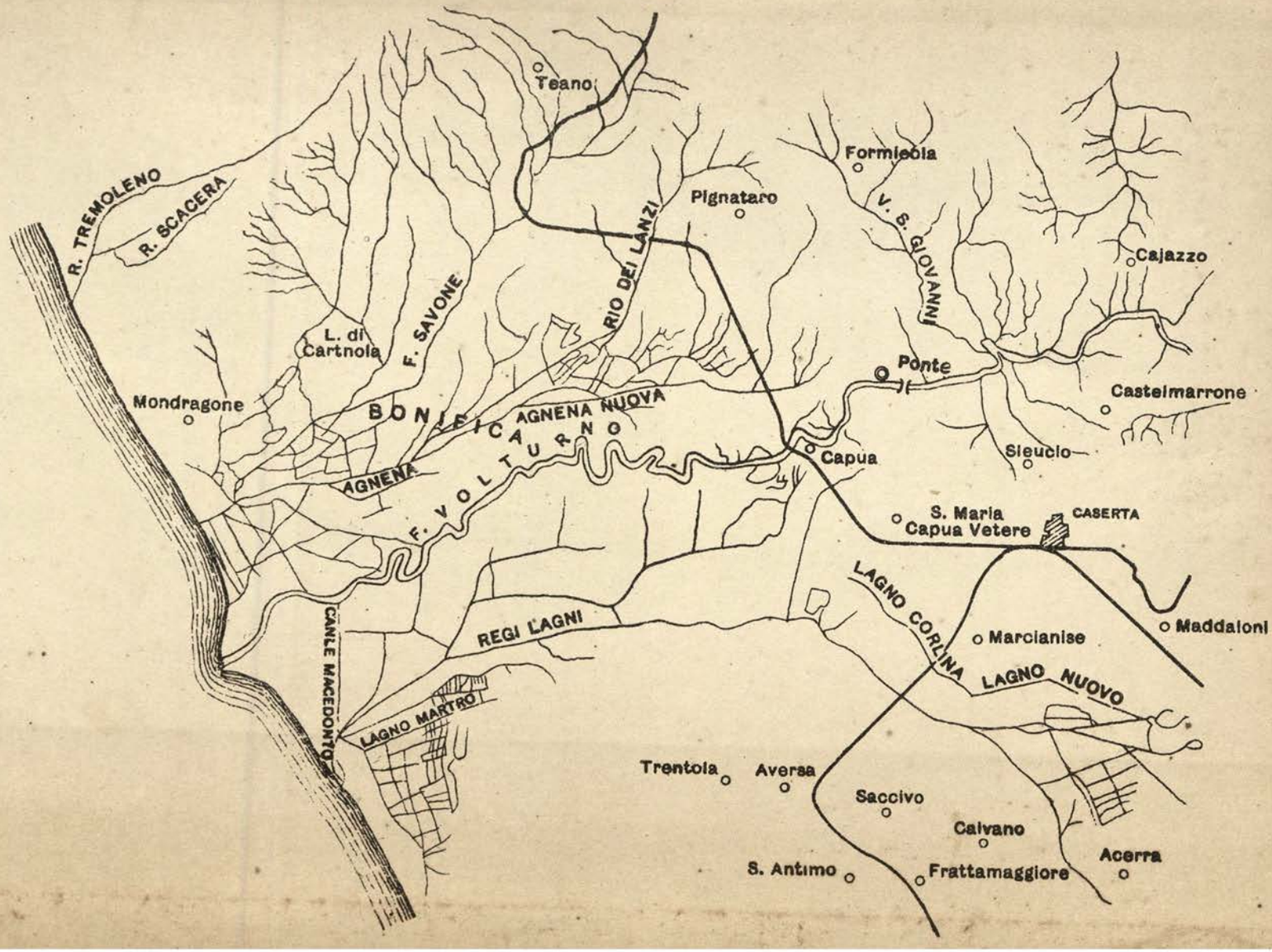


SECTION A B.

PLATE 4.

GENERAL PLAN OF BONIFICA OF LOWER BASIN OF VOLTURNO.

Scale $\frac{1}{250000}$.



PLAN OF THE LOWER BASIN OF THE VOLTURNO RIVER.

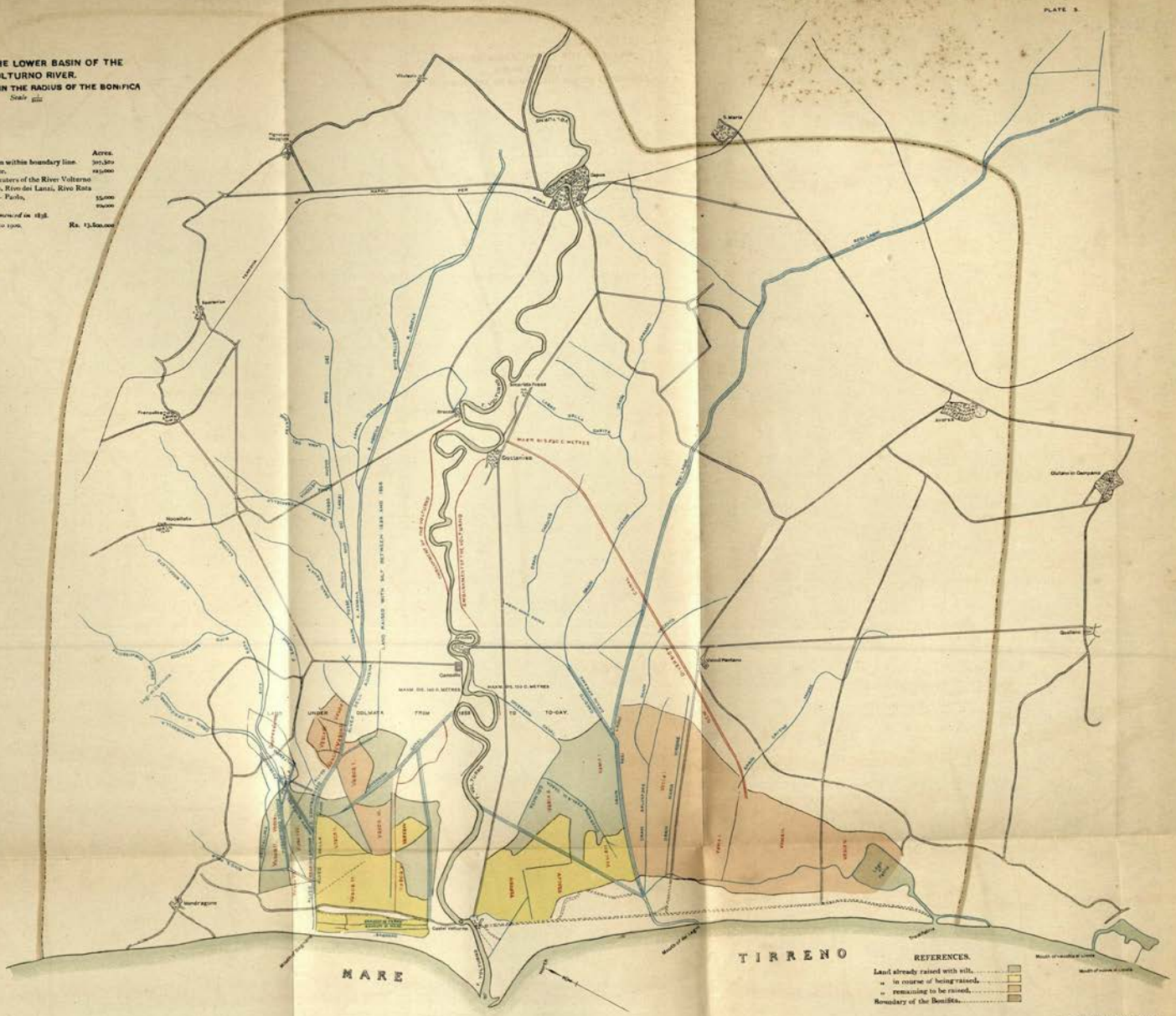
COMPRISED WITHIN THE RADIUS OF THE BONIFICA

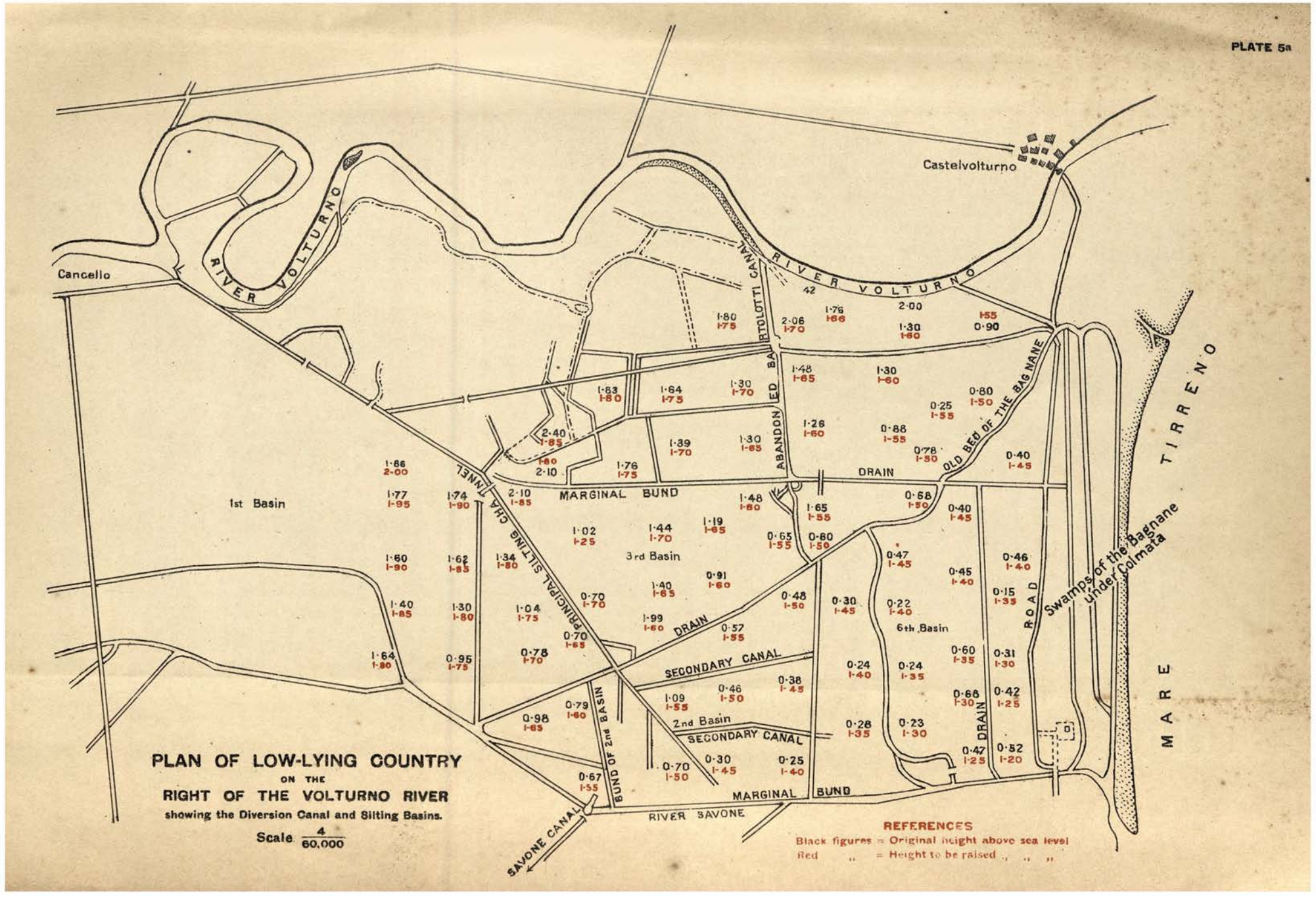
Scale 1/100

		Acres.
I.	Area of the drainage Basin within boundary line.	307,360
II.	Area improved by drainage.	125,000
III.	Area raised by the turbid waters of the River Volturno and the torrents Savone, Rivo dei Lanzi, Rivo Rata Fosseriecio, and Rivo S. Paolo,	55,000
IV.	Area now under Coltivata.	70,000

Works commenced in 1838.

Expenditure from 1838 to 1900. Rs. 13,500,000





PLAN OF LOW-LYING COUNTRY
ON THE
RIGHT OF THE VOLTURNO RIVER
showing the Diversion Canal and Silting Basins.

Scale $\frac{4}{60,000}$

REFERENCES

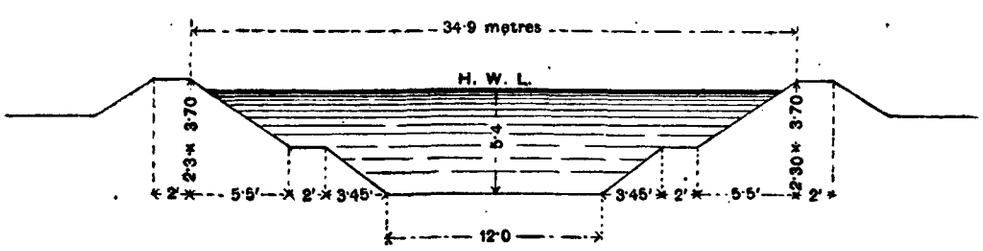
Black figures = Original height above sea level

Red " = Height to be raised " " "

PLATE 5b.

CROSS SECTION OF NEW DIVERSION CANAL FROM THE VULTURNO.

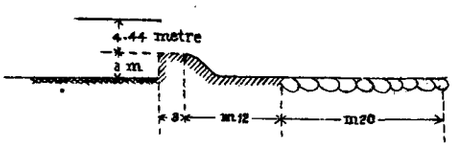
Max. discharge 7,100 cusecs. Slope 0·40 per °/₀₀



GENERAL PLAN
OF
BONIFICA OF GROSSETO AND PIOMBINO.
Scale. $\frac{1}{500.000}$

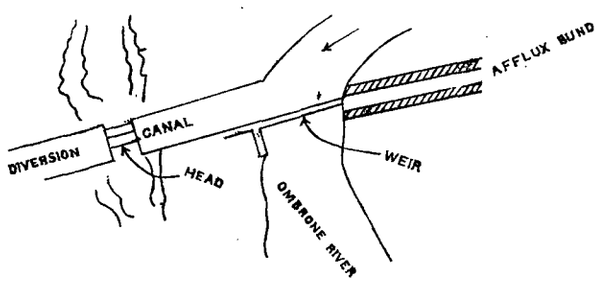
COLMATA OF CASTIGLIONE SWAMP

GROSSETO



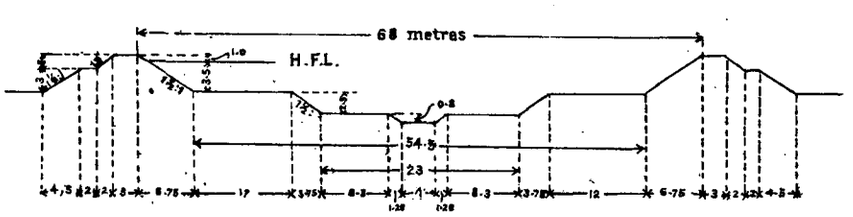
SECTION OF DIVERSION WEIR OF THE OMBRONE. LENGTH 150 ME:

FIG. 1



PLAN AT OFF-TAKE OF THE DIVERSION CANAL

FIG. 2



CROSS SECTION OF 2nd ENLARGEMENT
of
THE DIVERSION CANAL FROM THE OMBRONE

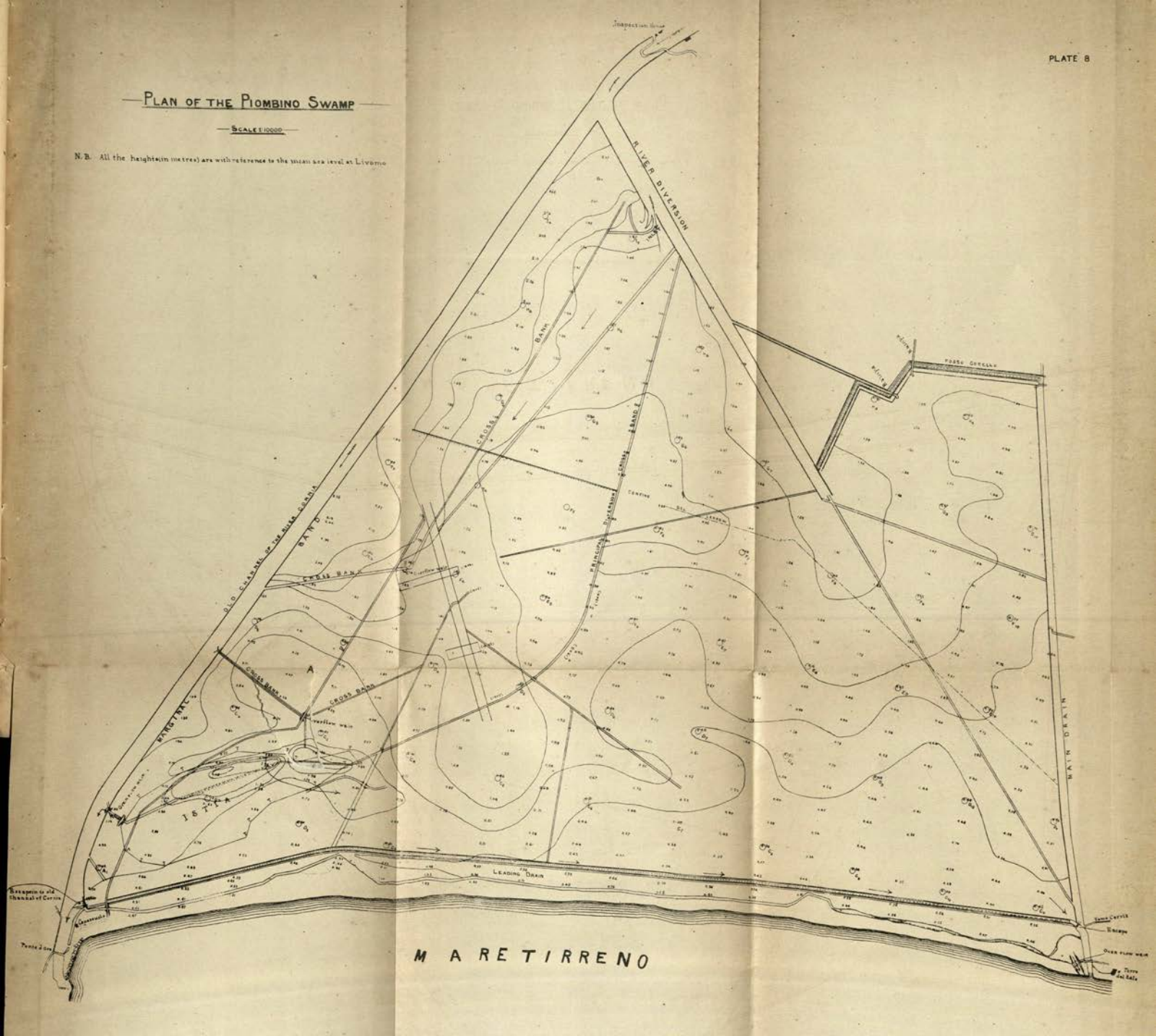
FIG. 3

PLATE 8

PLAN OF THE PIOMBINO SWAMP

SCALE 1:10000

N.B. All the heights in (metres) are with reference to the mean sea level at Livorno



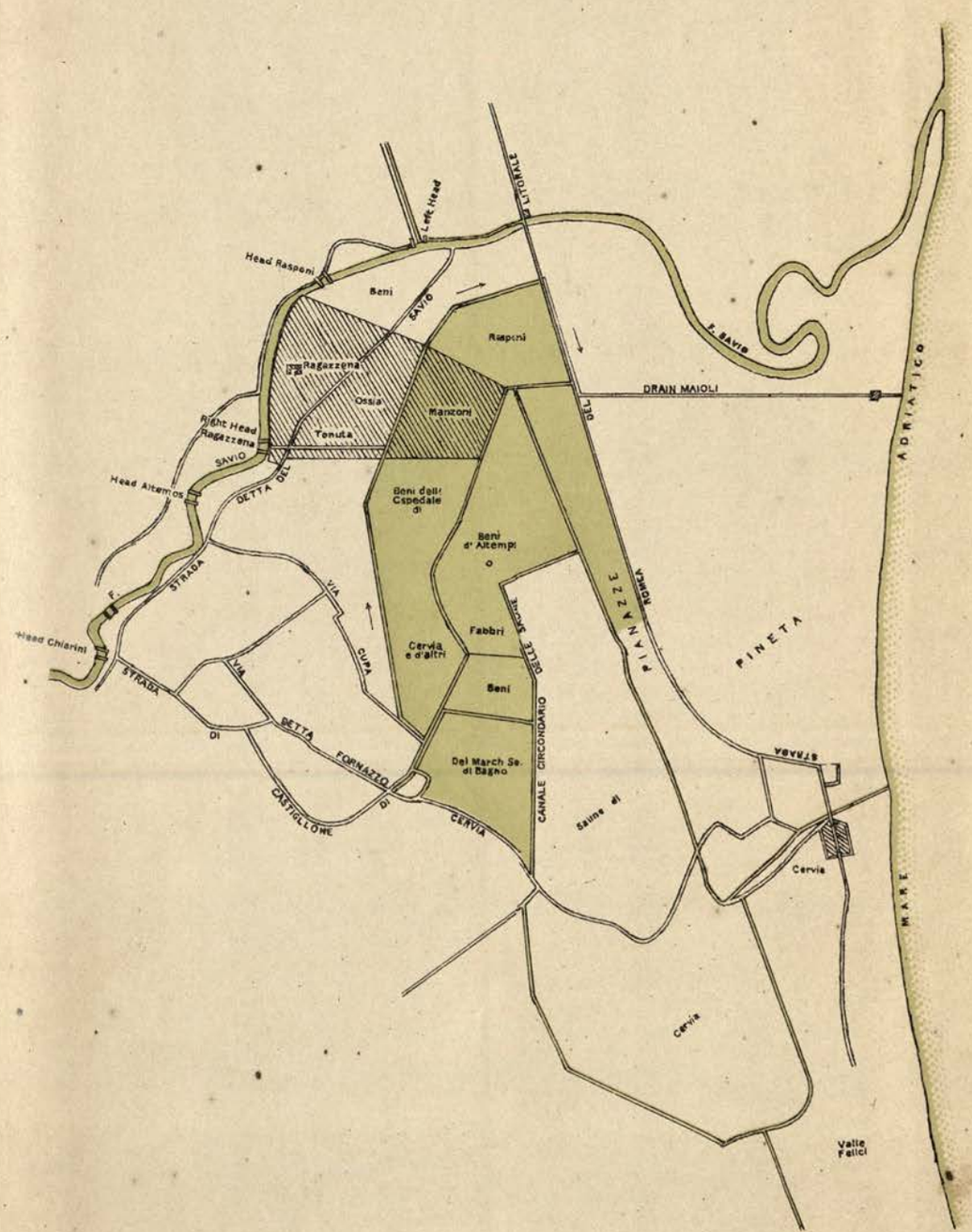
BONIFICA AT RAVENNA

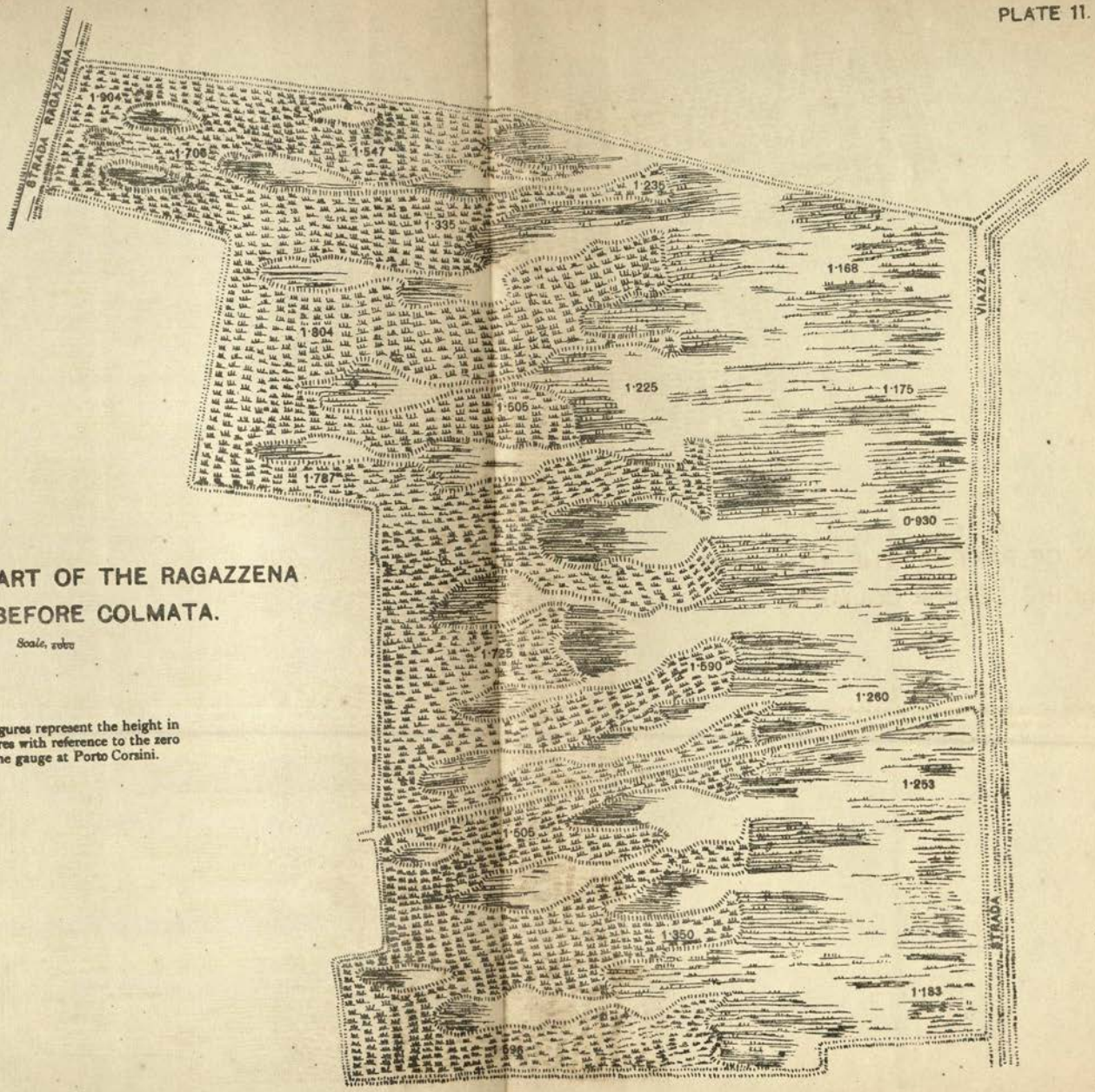
SILT BASINS OF THE LAMONE

Scale 1:100 000

GENERAL PLAN
OF THE
RAGAZZENA HOLDING.

The graen color represents the land which can be improved from the new head.





N

CONDITION OF PART OF THE RAGAZZENA HOLDING BEFORE COLMATA.

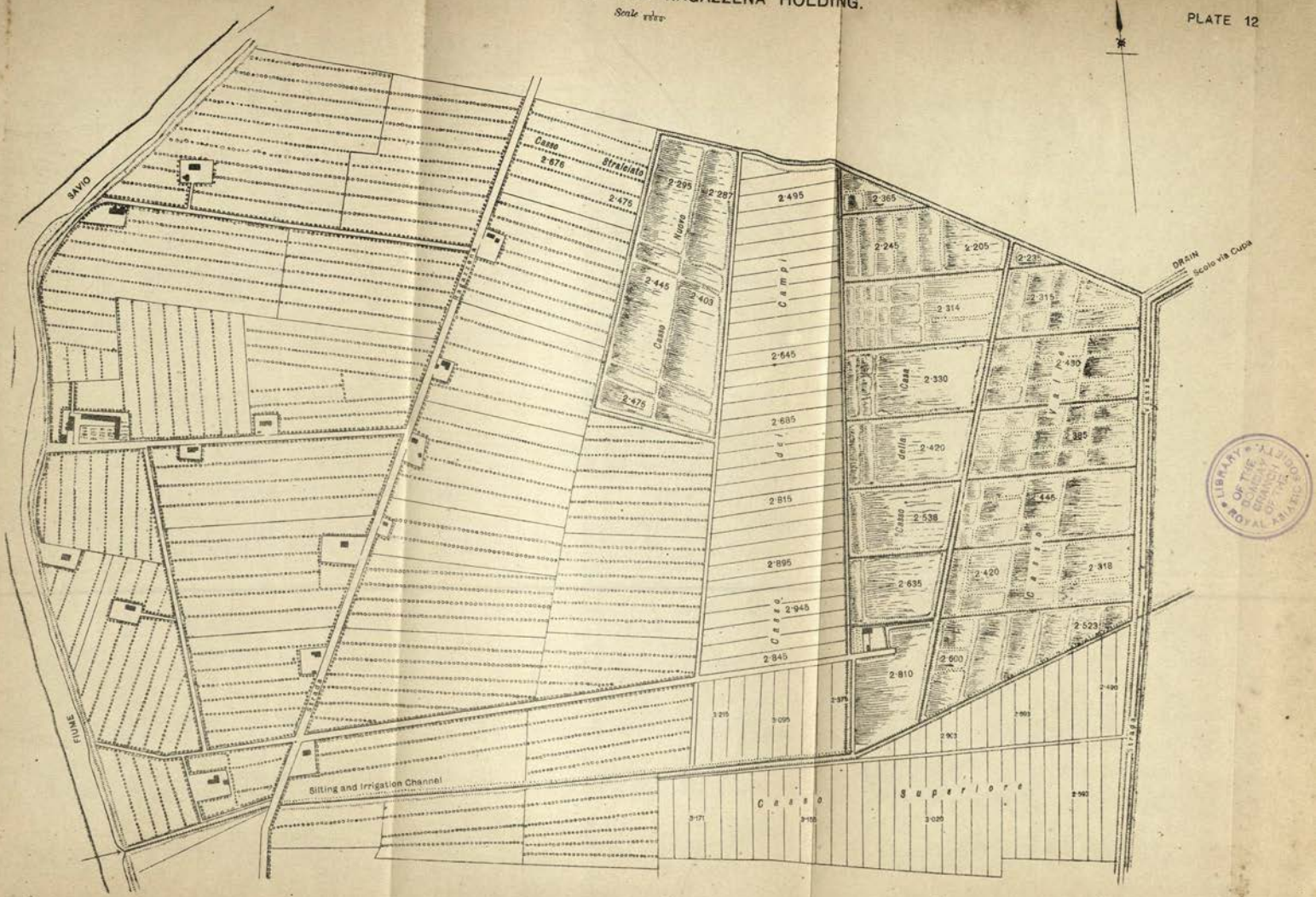
Scale, 2000

NOTE.—The figures represent the height in metres with reference to the zero of the gauge at Porto Corsini.

PRESENT STATE OF THE RAGAZZENA HOLDING.

Scale 1/250

PLATE 12



LIBRARY OF THE ROYAL ASIATIC SOCIETY

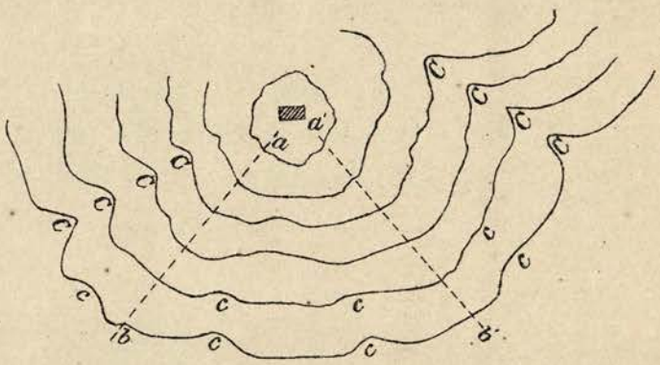


FIG. 1

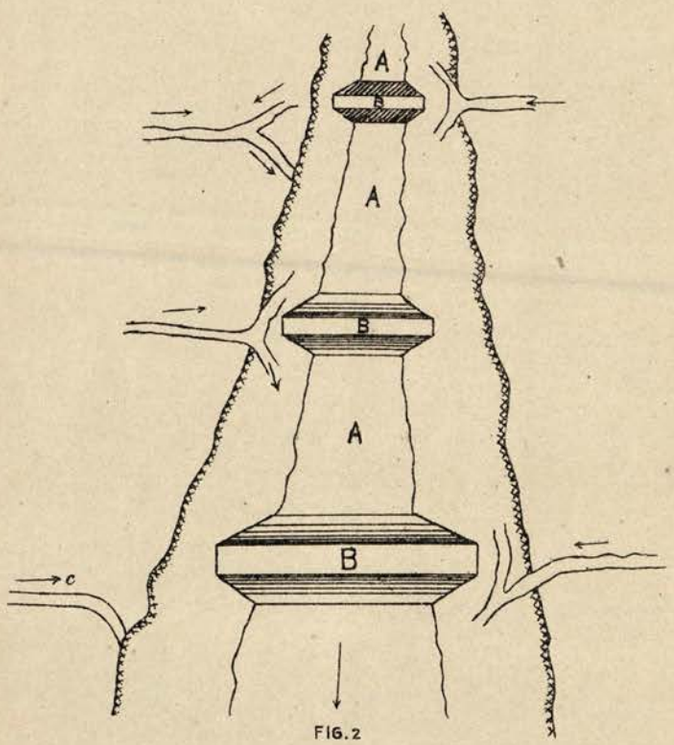


FIG. 2

DIAGRAMMATIC SKETCH OF SYSTEM OF SILT BASINS

A. SILT BASIN

B. BUNDS

C. SILT CARRYING CHANNELS

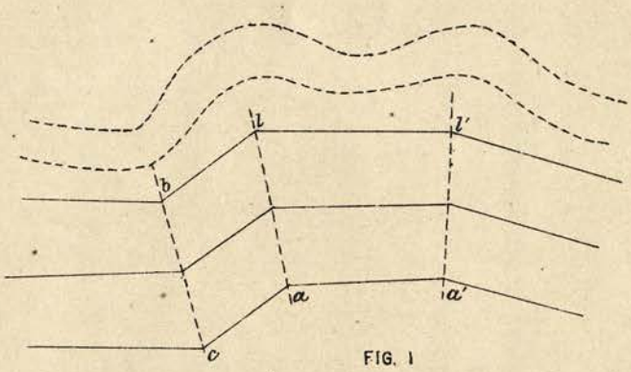


FIG. 1

cb, *al*, *al*. Lines of the points of spina

c closed spina

a a open spina

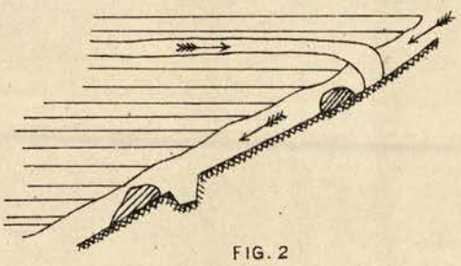


FIG. 2

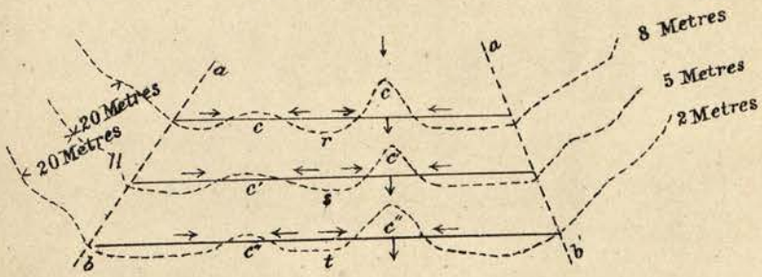
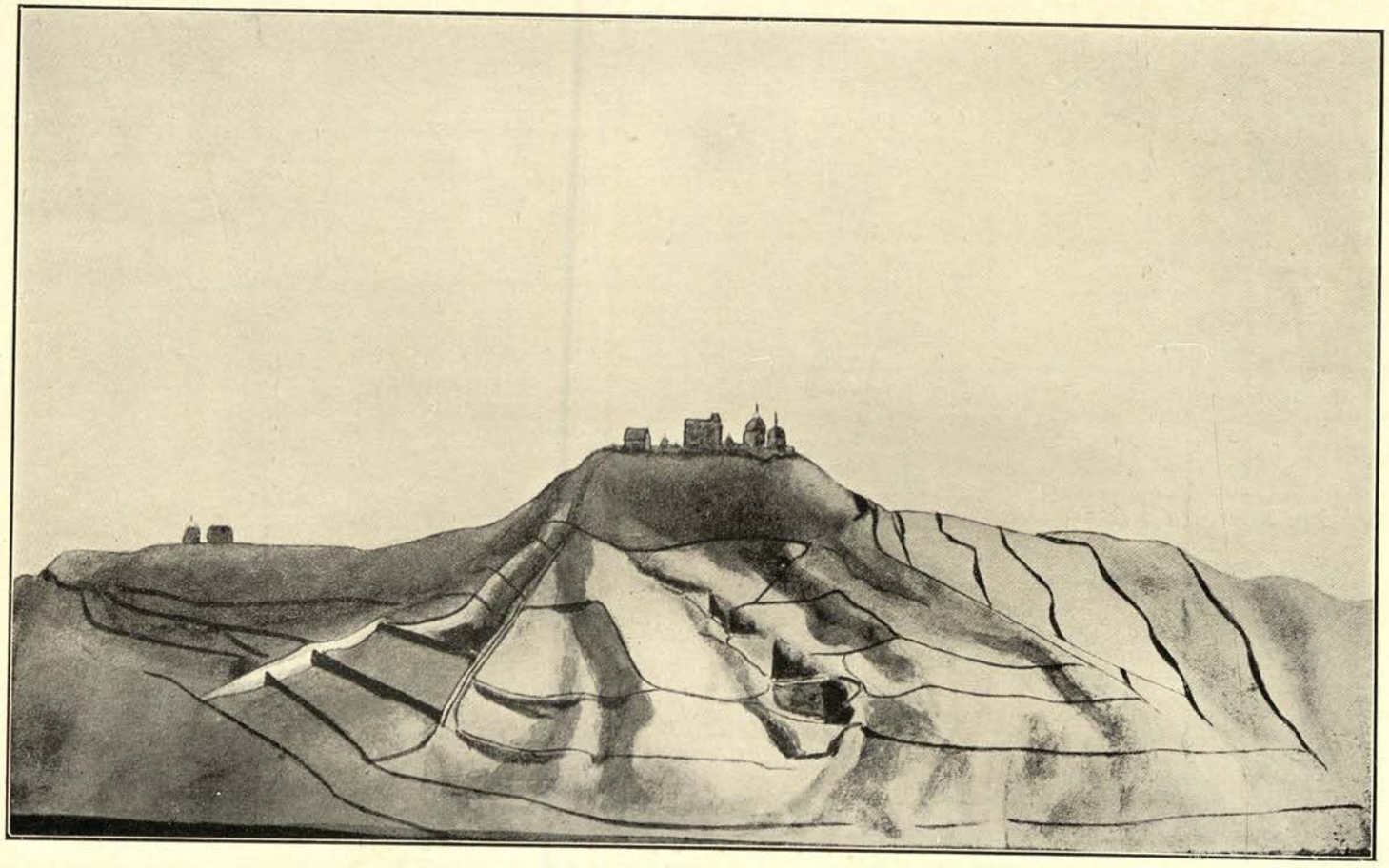
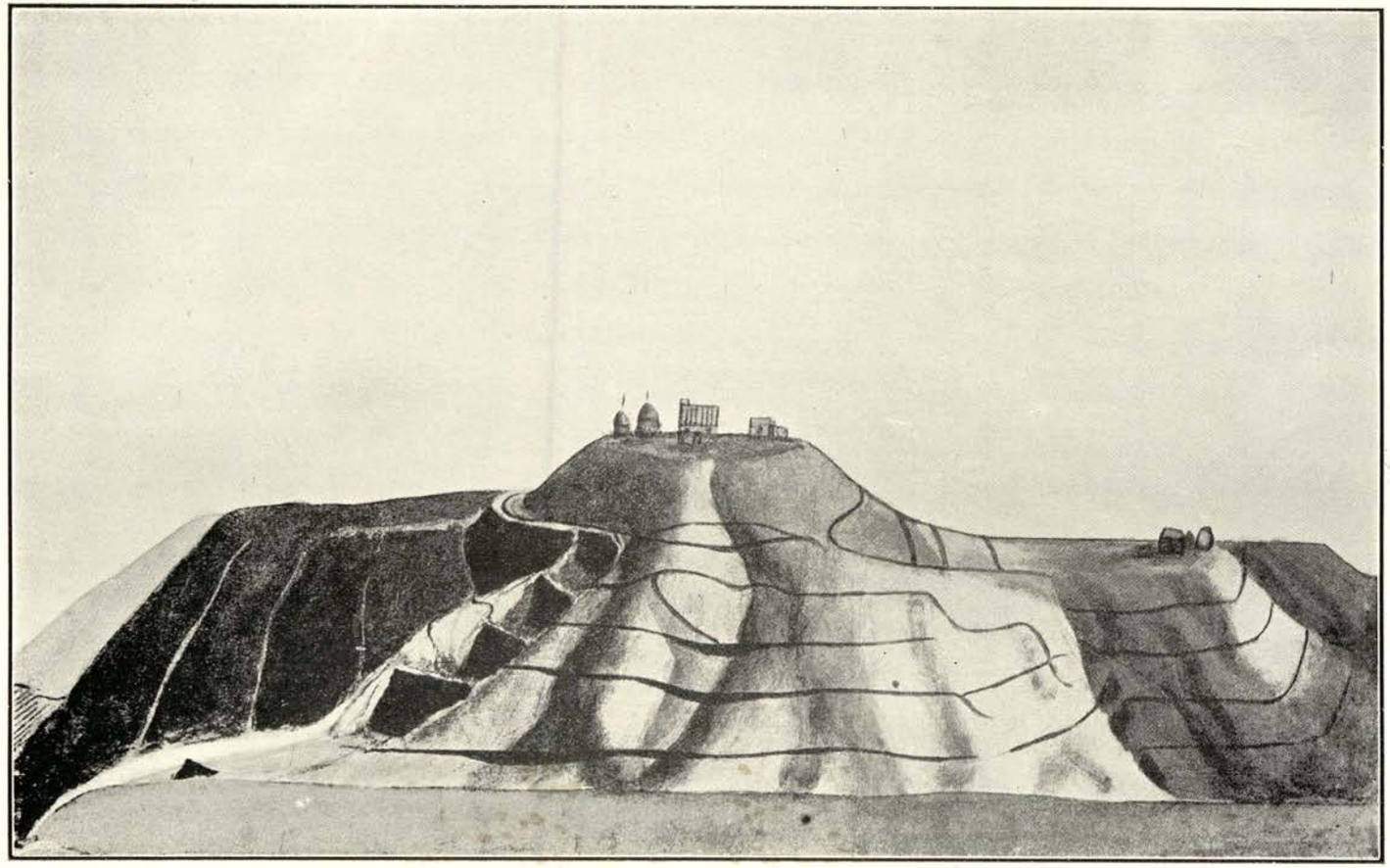


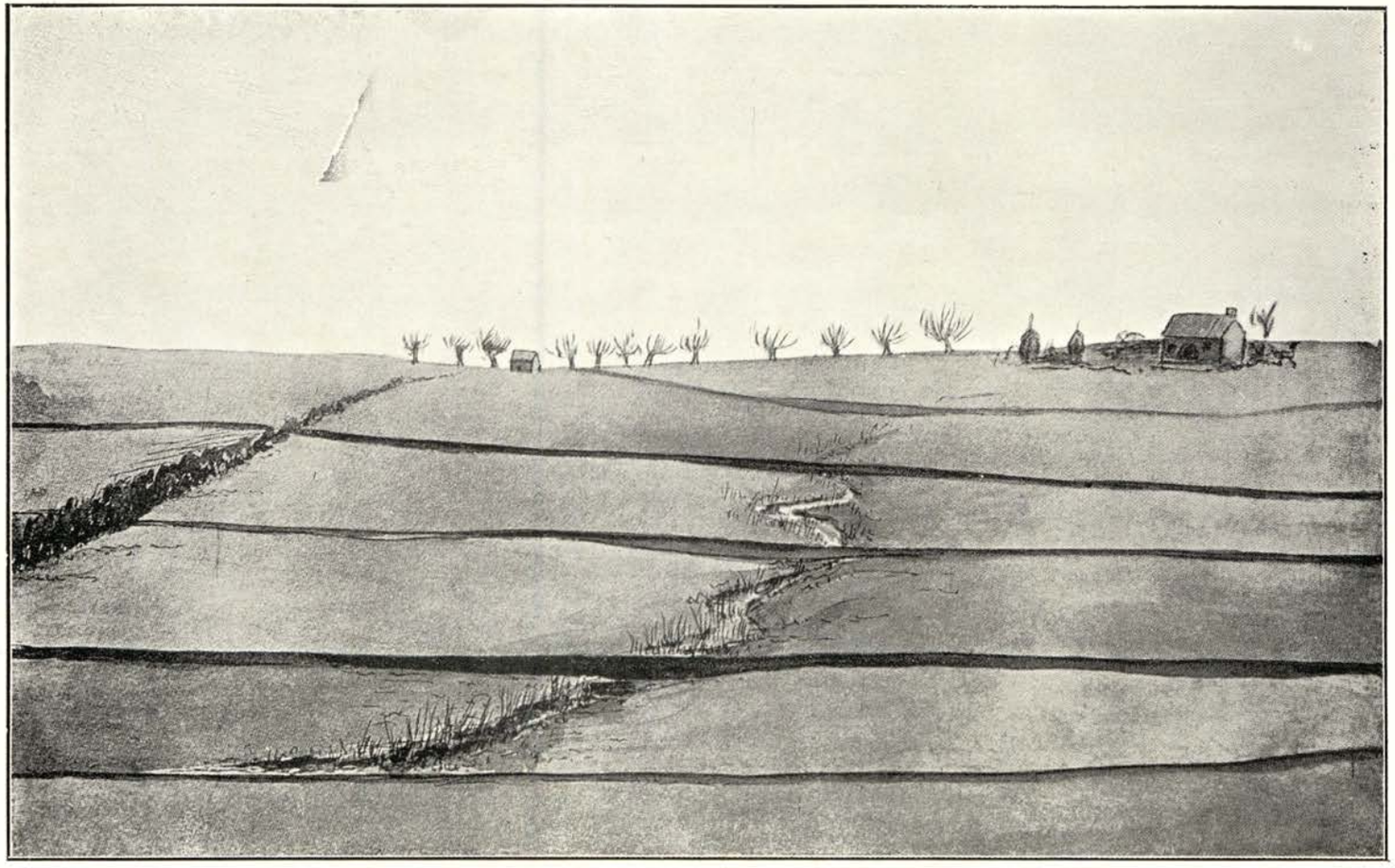
FIG. 3



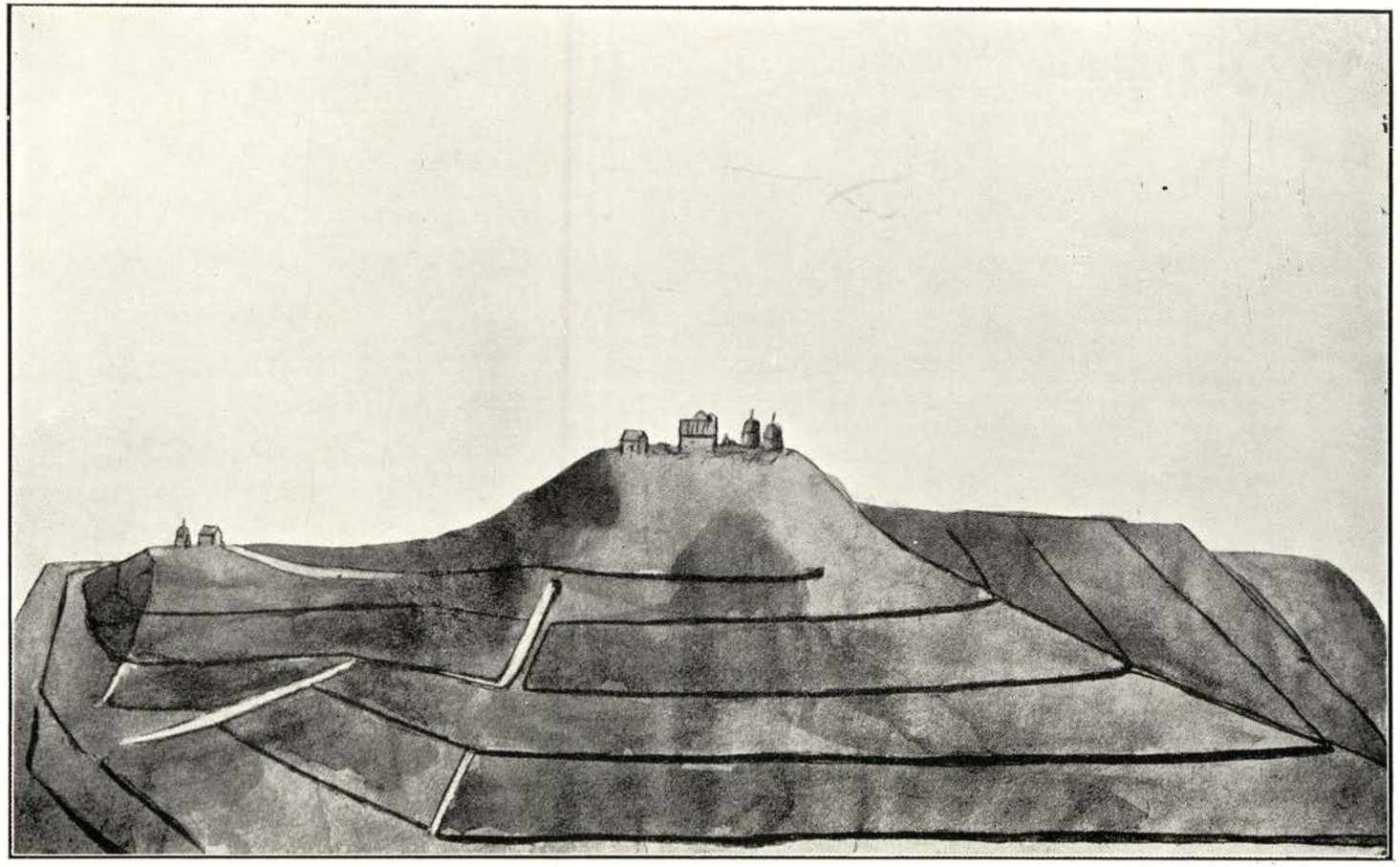
South View of Hill side showing the work of systemization "a spina" and also of Colmata.



North View of Hill side showing the work of systemization "a spina" and also of Colmata.



View showing Colmattelle and the ditches for the systemization "a spina."
Taken from a photograph on the farm of the Agricultural School of Macerata.



View of the same Hill side shown in Fig. 13 after completion of the work of Colmata.

PLATE 19.

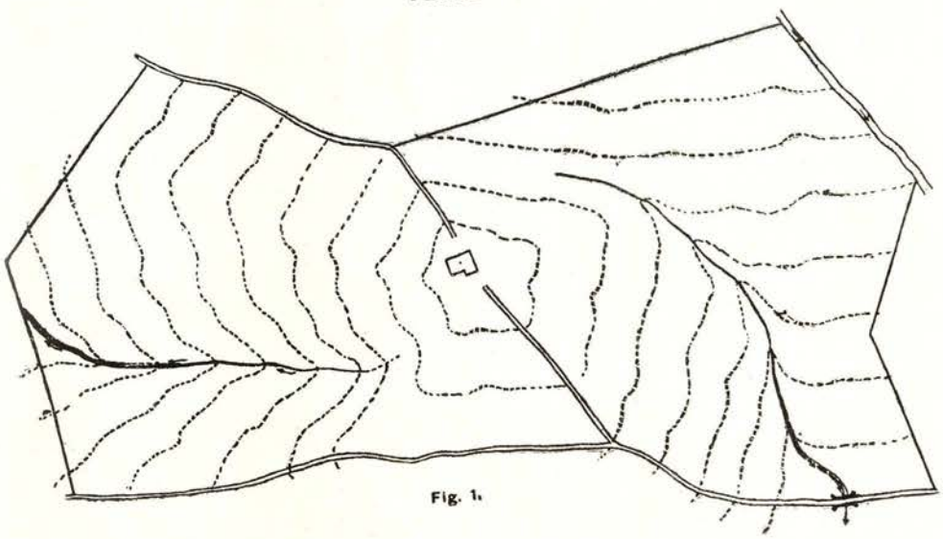


Fig. 1.

CONTOUR PLAN OF ESTATE.

PLATE 20.

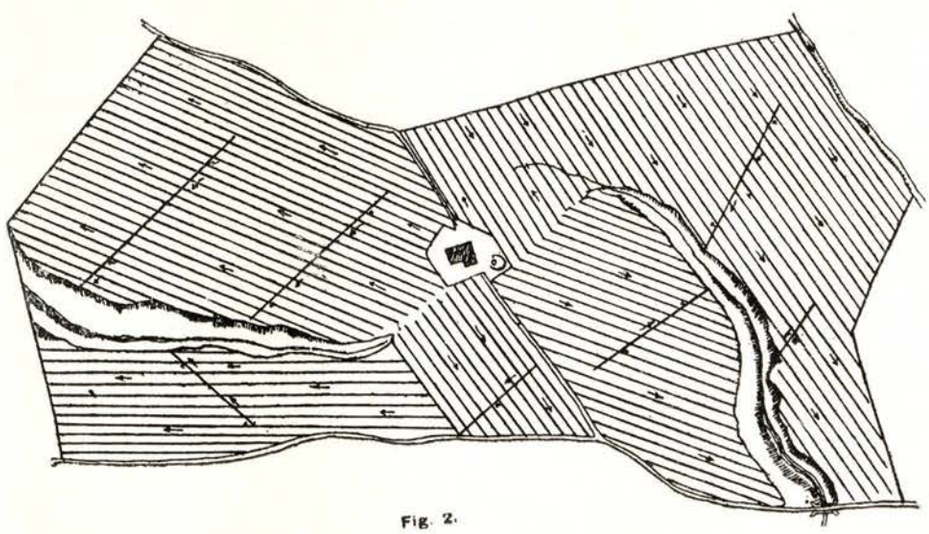
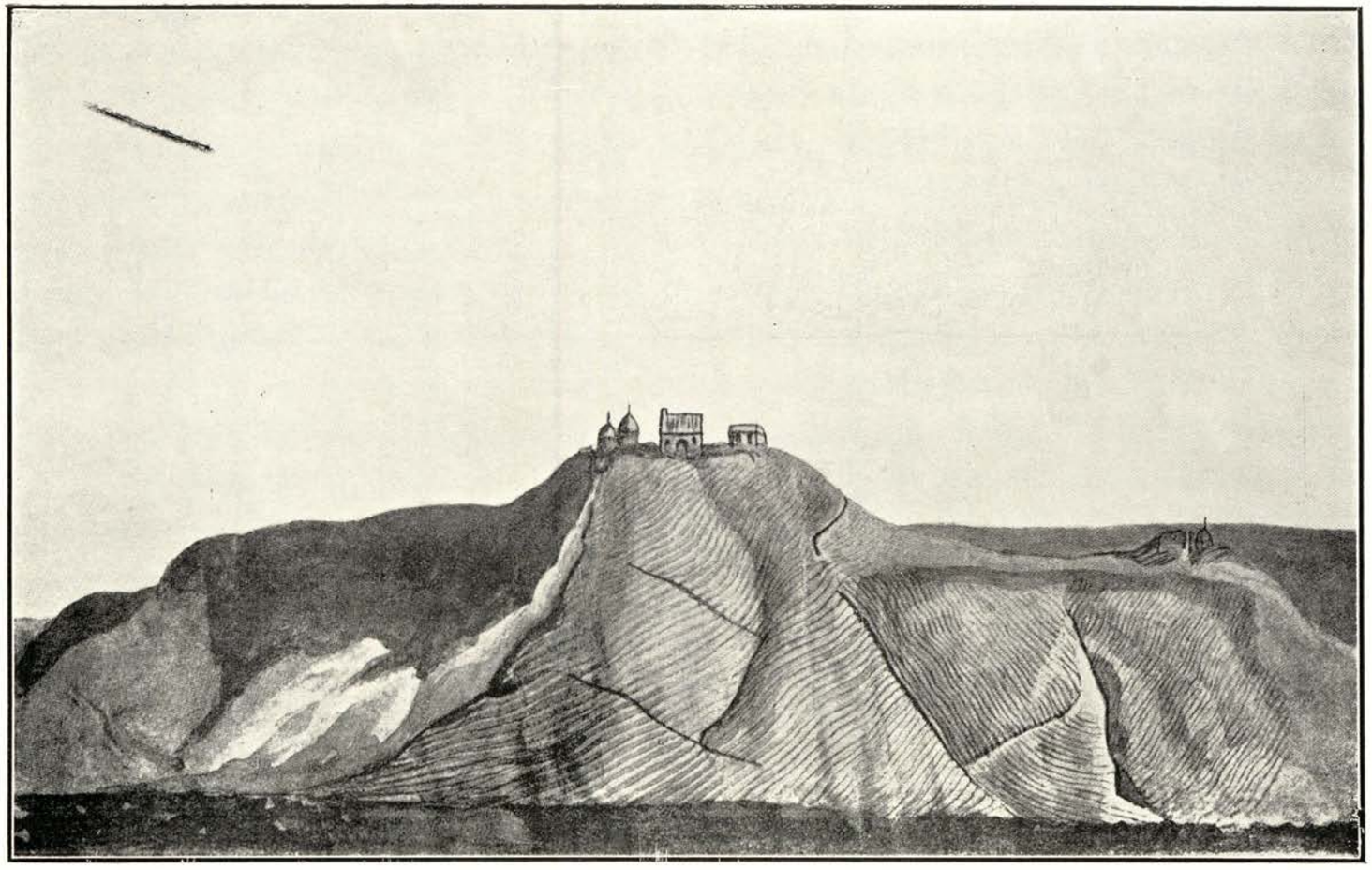


Fig. 2.

PLAN SHOWING CULTIVATION IN OLD STYLE.



Hill worked on the system of Rittochino.

PLATE 22.

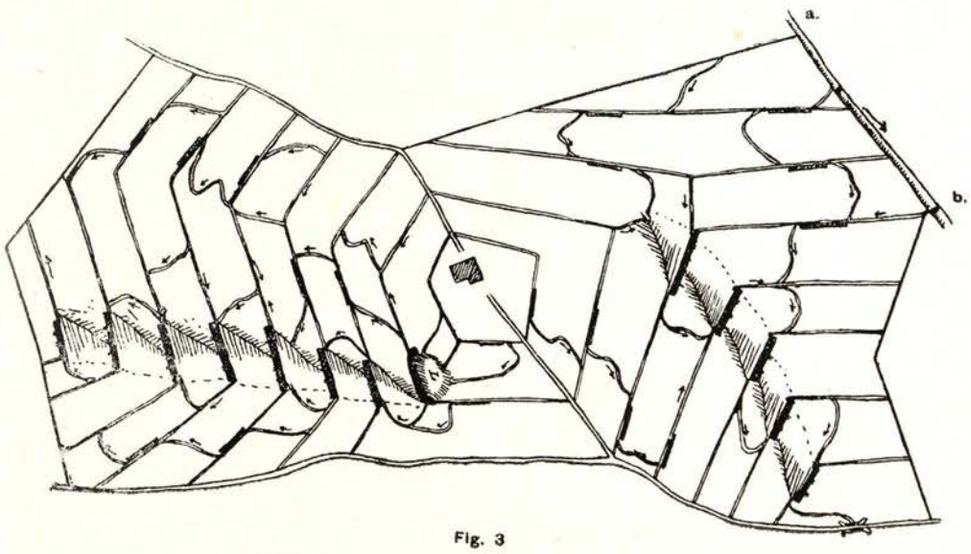


Fig. 3

PLAN SHOWING CONTOUR DRAINS AND BANKS.

PLATE 23.

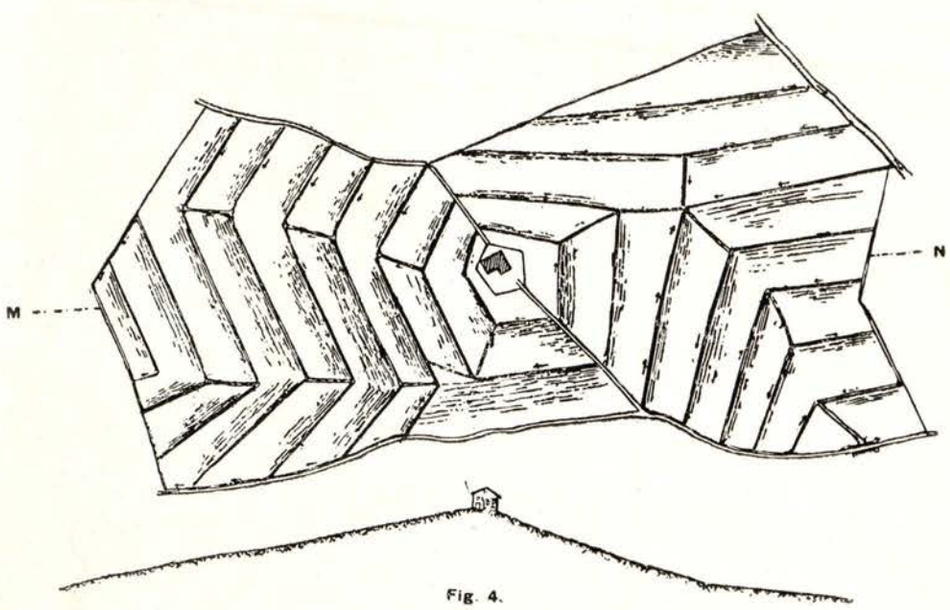


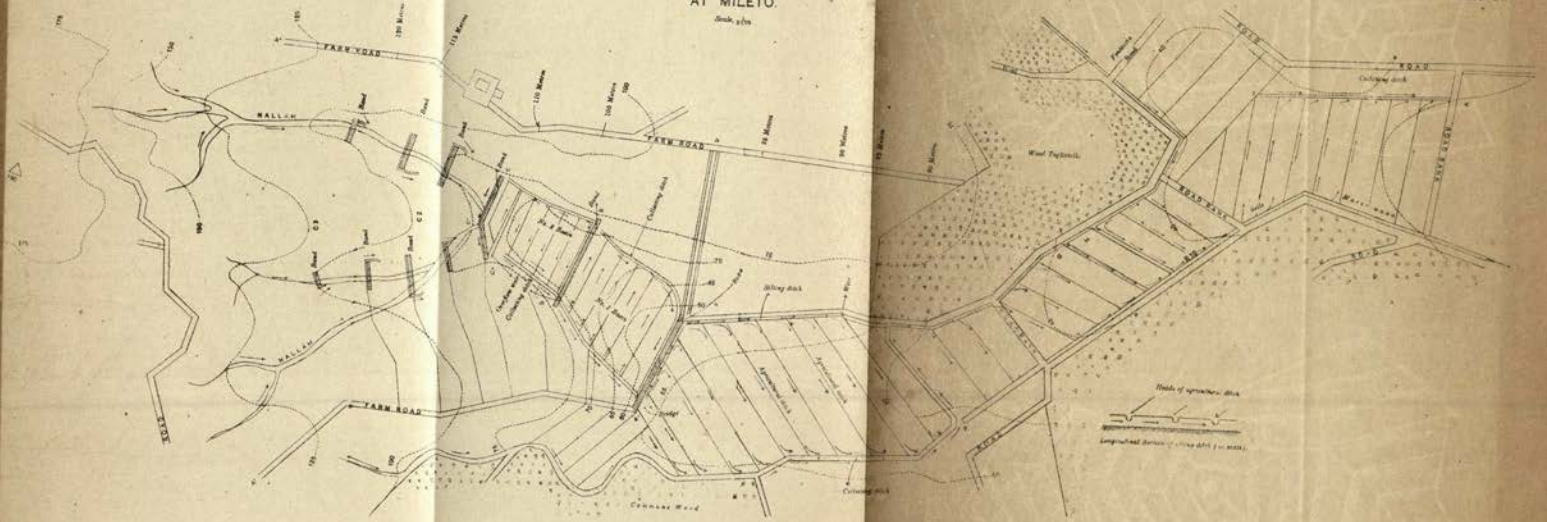
Fig. 4.

ESTATE WITH DRAINAGE SYSTEMATISED.

PLAN SHOWING SYSTEM OF COLMATA DI MONTE
ON A PORTION OF MARCHESE RIDOLFI'S ESTATE
AT MILETO.

Scale 2 Chs

PLATE 26


FARM ROAD
MALLOW
FARM ROAD
MALLOW
FARM ROAD
ROAD
ROAD
ROAD
Cultivated Land
Cultivated Land
Cultivated Land

high limit. The capacity of humus must vary, however, not only with the state of decomposition, but with its origin as well, since the pore space is the final determinant of its water-bearing capacity. The undecomposed litter, which covers the humus and from which humus is formed, does not exhibit the characters of humus toward water. It protects the humus, as humus does the underlying soil, from excessive transportation by surface water and in addition from excessive evaporation, acting as a mulch.

The accumulation of humus on forest soil depends, if it has neither been disturbed nor destroyed, on the kind of species forming the forest and to some extent on the soil, the destruction of humus proceeding rapidly on loose, porous soils, which permit freer circulation of air and afford the condition best suited for bacteriological activity, and since many species of trees, especially the white oak and chestnut, have a wide range of soil adaptability, their capacity to accumulate humus is modified both by their rate of growth on the soil and by the oxidizing capacity of the soil on which they happen to be growing.

APPENDIX No. V.

The following mechanical analysis of silt taken from the bed of the Ranjitpur Distributary, Cawnpore Division, Lower Ganges Canal, has been kindly furnished me by Mr. W. H. Moreland, C.I.E., Director of Agriculture :—

	In 100 parts.
Moisture and organic matter	3·74
Chalk	1·98
Sand, coarse and fine	83·71
Silt	6·66
Fine silt	1·20
Clay	2·27

No alkaline soluble salts were found. Silt and fine silt are used to denote the particles too fine to be classed as sand and too coarse to be taken as clay.

The Agricultural Chemist states that " the amount of ' clay ' and ' fine silt ' is very low. Soils containing less than 20 per cent. of fine silt and clay are generally found deficient in water-retaining capacity, and a large application of this on land already deficient in this respect would, I imagine, be risky."

The result of the inquiries I have had made among the cultivators confirm this.

The silt analysed would be identical with that cleared from the cultivators' gul, and is precisely similar to that caught in the silt traps.

The cultivators make little or no use of it : they consider it somewhat beneficial to clay lands for rabi crops, but harmful for heavy rice lands and lands with light soil, as it renders them more thirsty.

The amount of clay and fine silt is remarkably low, and compares very unfavourably with the silt in the Italian Rivers, the Lamone for instance.

The above facts appear to prove that the silt brought down the Lower Ganges Canal system and desposited in the irrigation channel and guls has little or no value as a fertilizer for the improvement of the light sandy lands which mostly predominate in this Doab.

SUPPLEMENTARY NOTE TO THE "REPORT ON UTILIZATION OF SILT IN ITALY."

BY

THE HON'BLE MR. C. H. HUTTON.

ALTHOUGH no works have been undertaken in these Provinces for the express purpose of silting up marsh lands in order to get rid of malaria, a good deal of work since the early eighties has been undertaken on the Ganges, Lower Ganges, and Eastern Jumna canals on the construction of silt traps, chiefly for the purpose of strengthening embankments in usar soil and incidentally for the reclamation of usar land.

2. In 1909 I was called upon to write a note on these silt traps and land reclamation works. The following are some of the results :—

Sixty-two acres have been reclaimed by silt outside the banks of the Cawnpore stump of the Ganges canal. The present annual rental represents a return of 5 per cent. on the cost of reclamation which amounted to 376·3 per acre. The average annual rental of this reclaimed land is Rs. 19 per acre which is high. At the tail of the same canal also, two silt traps were constructed for the reclamation of usar land. Both these traps were favourably situated for economical working as there was a free fall for the clear water into the Lower Ganges canal. The Ganges canal water, it must be here noted, carries more silt than the Lower Ganges canal ; the land also in both these cases was acquired at a cheap rate as it was almost wholly usar.

The cost of reclamation in the case of Nagla Hassan trap was Rs. 112 per acre, quite a moderate amount ; the present rental is Rs. 17·3 per acre which represents a return of 12·9 per cent. on the cost of reclamation.

The cost of reclamation, however, in the case of Nahrabad silt trap was Rs. 311 per acre, nearly three times the cost of the former, no reason can be assigned for this at this lapse of time, but it should not have cost nearly so much, seeing that the conditions were the same. The area of this trap was 12 acres, while that of the Nahrabad trap was 79 acres and large traps are undoubtedly more economical than small ones.

The land is now let at nearly Rs. 11 per acre which represents a return of 4·8 per cent. on the cost of reclamation.

On the Bhognipur branch of the Lower Ganges canal, 53 acres were reclaimed at a cost of Rs. 146·7 per acre and the land so reclaimed is rented at Rs. 7·4 per acre.

On the Eastern Jumna canal 157 acres were reclaimed at Gorhni by diverting the whole canal over this area of usar land enclosed by embankments.

The cost of reclamation was Rs. 171 and the annual rental of the reclaimed land is Rs. 9 per acre which represents a return of 5·3 per cent. on the cost of reclamation.

The conditions were very favourable, as it was found possible to divert the whole canal, which is a small one, through the area to be reclaimed ; the canal too runs almost continuously throughout the monsoon and carries a very large amount of silt. Indeed it was for the purpose of ridding the canal and distributary channels of silt that this work was undertaken.

On the Lower Ganges canal two large silt traps have been operated since July 1906, *viz.*, the Harnaut trap 406 acres, and the Piyaoli trap 211 acres.

The expenditure up to date in the case of the former has been Rs. 63,966 or Rs. 157 per acre, and in the case of the latter Rs. 38,710 or Rs. 183 per acre. Neither of these traps are favourably situated for economical working, as in order to run a sufficient volume through them it is necessary that there should be full or nearly full supply in the canal during the flood season, when alone the river water carries any useful amount of silt. It is impossible to admit full supply into the canal during the monsoon unless at the same time there is a good demand for irrigation, as the canal escapes are not designed to surplus the full supply volume of the canal back into the rivers. The working is, therefore, somewhat intermittent during the flood season and the operations in consequence are likely to be prolonged and costly.

3. In order to be able to carry out land reclamation by the process of colmata or warping up, at a cost which will repay the operations, three conditions are necessary :—

(1) Large areas to be dealt with.
(2) Large volumes of heavily-laden silt water which can easily be diverted into these areas and be easily got rid of when they have deposited their silt.
(3) A good command of levels to avoid as little handling of the silt as possible.

These conditions in the neighbourhood of our canals are rarely to be obtained.

4. In considering the figures given, it must be mentioned that a good deal of Government land was included in the silt traps and that the cost of this has not been included in the returns given, also that interest on the expenditure during the process of warping up has not been charged, and as the operations were greatly prolonged the interest charges would have amounted to a considerable sum and have reduced the percentage of return. It is clear, therefore, that the reclamation of land in the proximity of our canals by silting is only likely to show a fair margin of profit when the conditions are exceptionally favourable.

The expenditure in such cases is limited to the cost of land, the embankment round the silt trap and the cost of operating ; but if works were constructed solely for the purpose of reclamation, the cost of a diversion weir and a certain length of canal would have to be included and such works would unquestionably not pay.

Our experience here shows that the land even when reclaimed is not likely to be let at an annual rental of more than Rs. 10 to 12 per acre ; in some exceptional cases it has been let at Rs. 25 per acre, but in the Etawah branch the average rental of 366 acres of reclaimed land is only 6·5 per acre. It must be noted too that all these reclaimed areas have the advantage of being irrigated by lift from the canal on the payment of the usual water rates.

With a letting value of Rs. 10 to 12 per acre the cost of reclamation must not be more than Rs. 250 to Rs. 300 in order to return 4 per cent.

5. It is in my opinion doubtful if the reclamation of usar land by the deposit of 2 or 3 feet of silt on it is likely to be permanent.

The usar soil itself due to the presence of salts is nearly impermeable, the embankments formed round these areas and made of the same soil are also impermeable.

Silt has been deposited to a depth 2′ to 4′ within, as it were, an impermeable basis.

In the course of time water-logging must inevitably cause the salts to rise by capillarity to the surface and eventually the condition of the soil will be no better than before. There are plenty of instances in the silt traps of the Mainpuri, Etawah and Cawnpore divisions to show that this is already taking place. The practicability of permanently reclaiming usar land by the deposit of 2 to 3 feet of silt on it is more than doubtful. The question as to whether such land can be reclaimed temporarily for such a period of time as will not only repay the interest on the expenditure but will suffice to extinguish the capital cost, cannot be answered definitely as we do not know how long it will be before the land will return to its original unfertile condition.

In my opinion it will not pay to reclaim such land even temporarily unless the conditions are exceptionally favourable.

The question of improvement of usar lands in other directions has been fairly exhaustingly considered by the Agricultural Department and Mr. W. H. Moreland, the late Director, informed me that the results so far are entirely negative.

There is a sound agricultural maxim current in England which should not be forgotten, *viz.*, that it does not pay to put good money into bad land.

6. In section IV, paragraphs 5—9 of my report on the utilization of silt in Italy, I have set forth the reasons why the conditions in that country are so favourable to the reclamation by warping.

It was impossible to obtain figures of the cost of most of such reclamation as the work in many cases has been going on for many years, but it is very doubtful if it has in most cases been financially successful. It must, however, be noted that the Italian Government undertook these works for the sole object of getting rid of malaria without regard to financial results and in this respect the works no doubt have been a success.

In the case of Ravenna reclamation works which were commenced in 1840, the cost of reclamation appears to have been Rs. 187 per acre, a moderate figure, while on the other hand the reclaimed land lets at about Rs. 70 to 80 per acre, which is seven or eight times as much as can be expected in these provinces.

REPORT ON THE "COLMATE DI MONTE" OF ITALY.*

BY

MR. F. CLAYTON,

Executive Engineer.

1. IN Italy it has long been recognised that the direct action of rainfall on hillsides deprived of forest or other vegetable growth is of a most injurious nature. The good soil on top is washed down into the valleys and so into the streams, and by them is carried away to the sea and lost to cultivation, while at the same time the drainage on the hillsides tends to form ravines and landslips and so to cut up and destroy much land that could otherwise be put to a profitable use. Owing to there being no cheap coal for general use in Italy the forests have mostly been gradually destroyed and the condition of many properties in the hills—and Italy consists chiefly of more or less hilly country—has in the past gone from bad to worse. The evil was recognised, but for long no remedy was found except in the expensive process of terracing by hand labour, which indeed saved for cultivation the land that was left, but did not improve the conditions of land which had already become cut up by ravines or denuded of the best part of the soil.

2. There being as a rule no subsoil drainage, the only way in which the fields were, and still are, drained is by a series of deep furrows at intervals leading to a ditch at the end of the field, and so into a line of drainage and the nearest stream. In flat country this system acts well, though subsoil drainage is much more productive and enables the crops better to withstand a prolonged drought. In hilly country, however, the practice in the past has nearly always been to plough up and down hill along the line of greatest slope, by which method much soil is washed down the furrows and carried away to the foot of the hill. Where, owing to the steepness of the slope, this action became most marked and the fields began to deteriorate to a serious extent in consequence, a cross drain was made at intervals with the plough so as to divide the slope into sections, and to some extent do away with cumulative action of the drainage off the field.

3. The first attempts at rectifying this system were by making a series of transverse drains approximately following a contour line. In the early attempts, however, these were made to follow all the windings of the hillside, making cultivation difficult from the irregularity of the fields, and aggravating rather than improving the conditions in the depressions by the increased amount of water thrown into them. In the early part of the 19th century, however, a better system was devised by which the following changes were made (I omit for the present the bigger work of filling up the larger ravines) :—

(*a*) Instead of ploughing up and downhill the fields were to be ploughed along contour lines. This prevents most of the wash-down off the field surface.

(*b*) The depressions and ravines were banked below the junctions of the contour drains. This prevents the wastage from the action of drainage in the depressions by reducing its silt-carrying capacity and stops its destructive action in the formation of ravines.

(*c*) Part of the drainage water was passed from one contour drain to another along the spurs, by which means the prominence of the spurs was reduced by scour and the depressions filled up behind the banks by the deposit of the silt so obtained.

By these means the irregularity of the hillside can be reduced and the cultivation of the slopes between the contour drains made much easier. I would note that the contour drains are rarely further apart than will give a difference of level of 12 to 15 feet.

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* Report submitted to Government, 1909.

4. When the minor depressions have been fairly well filled up they are cultivated and the land is then considered to be systematized, though the filling process still continues to a small extent in the hollows. In this condition the hillside consists of a series of slopes divided transversely by ditches running nearly on contour lines (they usually have a slope of $\frac{2}{100}$). Water is passed from one contour drain to the next by a small drain at the end of the field which descends in a series of turfed steps, or by an oblique drain crossing the intermediate slope at an angle so as to reduce the gradient. Having reached the second contour drain the water flows along to the other end of the field, where it is again carried down. By this means as long a course as possible is provided for the drainage and the velocity with which it leaves the hillside is greatly reduced, while any soil brought down is deposited along the contour drains. At Meleto, where this system was first invented and in several other states I visited, there are no masonry works whatever used. This of course would be impossible in India with its far greater intensity of rainfall.

5. So far the work described is almost entirely systematizing the drainage on the hillside, and in some cases this has been found to be all that is necessary to enable landowners to utilize land, before almost unculturable, and in every case has added largely to the productiveness of the land. When systematized, the remaining work is carried out very gradually; the drains are cleared once a year, and the silt deposit in them is thrown out on the downhill side, and ploughed in. The ploughing is done in such a way as to gradually work the soil down towards the lower side of the strip, so that in the course of years the slopes intermediate between the contour drains are formed into terraces with a slightly sloping top. The final object is to attain by these simple means a series of terraces with the surface slope slightly towards the hill. I give in Figs. 1 to 5 some illustrations taken from a handbook on the subject by Dr. M. Conti, which show well how the final object is gained by means of systematization of the drainage.

6. The above is the main object aimed at on most of the estates I visited. There remain two questions which are most important with reference to the adaptation of Italian methods to Indian conditions, *viz.*, the filling up of the larger ravines and the prevention of landslips and of the formation of ravines. Of the former work, I saw many examples in various parts of the Apennines, which differed somewhat in treatment according to the nature of the hillsides, and of the latter, I saw three or four examples also treated very differently. The difference of method in the former being largely due to the different sorts of escapes used, I will deal with them in order according to the escape designs.

7. The filling up of ravines is accomplished by making a series of low banks across them, usually only about 3 feet high to start with. These are provided with an escape channel in soil at one end, and in some cases with a supplementary flood overflow at the other end with its silt about a foot higher than the main escape. The drainage coming down the ravine is headed up by these banks, fills up the small reservoirs so formed and deposits its silt, while the surplus water flows on into the next basin. If sufficient silt is not brought down in the ravine itself, or if it is desired to reduce the prominence of spurs on either side, the drainage off the hillside is collected in contour drains and conducted to the spur some distance above the bank, and is then turned straight down the spur. Thus it scours out the spur and at the same time acquires the silt needed to fill up the reservoir. By this means the reservoir is silted up a foot or two, and then the bank is raised another 3 feet, new escapes made, and the process begins again and proceeds till in time the height of the bank is sufficient to enable the whole ravine to be cultivated, except the dividing banks and on these trees are grown. In some cases the final height of bank attains as much as 30 or 40 feet above the next basin. The chief things to be noted are that the banks are raised very gradually, so that there is never any great depth of water behind them, and consequently but little fear of damage by failure of the bank, and that cultivation of some sort is usually quite possible long before the final height is attained. Cultivation is started as early as possible so that the outlay may not remain unproductive longer than can be helped. This is the most usual system, though with the well and fall systems of escapes, to be described below, the banks are often built at once to their full height; such works, however, require comparatively expensive masonry works and are not of the simple and cheap sort usually adopted.

8. An excellent example of systematizing, combined with ravine regulation, was on the Son Vinanzio property of Count Faina between Perugia and Orvieto. An amphitheatre high up in the hills, which is now largely under cultivation, was,

a few years ago, a bare hillside covered with scrub jungle and intersected with ravines. After clearing the jungle, drains were made to collect silt from a part of the hill further up so as to bring down extra soil and transverse drains were cut along contour lines, with the usual slope of 2/100 and at the usual intervals of 12 feet difference of level. These crossed innumerable small depressions which were blocked with dry stone walls about 3 feet high as a maximum. Soil quickly accumulated behind these and they were raised where necessary until in four or five years the depressions were sufficiently filled up for the contour drains to be made continuous on either side up to two main ravines, down which all the water escaped. Then these were treated in the same way, except that in them the bed was thickly sown with poplars so as to check the force of the water. As soon as the drains were made, a farm was started and the hillside lower down attacked, till now, some thirteen years since the work was started, there are two flourishing farms on the formerly waste hillside, and work is still going on below. The hillside is now a series of drains crossing the former depressions on dry stone walls with sloping fields between them (across what were the depressions also), these escape into two ravines which have a series of dry stone falls with a healthy grove of poplars in the basin above each. The work here was of a somewhat more expensive nature owing to the use of stone, but this was inevitable owing to the steepness of the hillside, and as the ground was very stony and the walls were made only of stone picked off the surface the extra expense was not great.

9. The above is a special case which I have noted before proceeding with the consideration of the question of ravine filling which I now resume in continuation of paragraph 7. Most usually the escapes are of earth only, this being rendered possible by the comparatively small amount of rainfall that ever occurs in one day, the maximum of which I was able to obtain any figures being about 3 inches in the 24 hours. In these cases where the escapes are of earth, merely turfing the bed is usually found to be sufficient, but occasionally a little brushwood is used to check the force of the water. There being no great depth of water in the reservoirs, even if the bed did cut out, no great damage could be done, but such scouring action is rare.

10. In other cases the descent from one basin to another is effected by means of cement tubes, and from the lowest reservoir a masonry-lined channel to the stream below. These tubes are 3 feet long and usually a foot in diameter. They are made two inches thick, the ends being socketed, so that they can be laid in soil without any lining (being laid to a steep slope). The only masonry used with these, is a wall at the bottom which is built as a couple of pillars about 5 feet apart, the intermediate space being spanned by an arch, and the outlet being over the centre of the arch. This form of construction is used as there is no cistern to stop the swirl made by the descending water, and there is considered to be less likelihood of failure than there would be with a continuous flat foundation. The bank above is carried out parallel with the hillside to a sufficient distance to secure the toe of the bank from danger from scour, and the pipe is laid parallel to the axis of the main bank and carefully parallel to the average slope of the hillside. The object of this is that as the bank is raised the pipe can be lengthened and the bank raised, and yet they will remain always at the same distance from the hillside as at first. Fig. 6 shows a sketch of these pipes and the method of raising the main banks as adopted at Cadiroggio. Fig. 7 shows a plan of the banks, etc., at this place, and Fig. 8, the longitudinal section of the ravine as it will be after the work is completed. Fig. 9 gives a good idea of the same ravine in process of filling and shows well the desolate character of the hillsides which have to be worked on. Practically all these hillsides are now cultivated with lucerne and other fodder crops, except the extreme top of the ravine and the clay cliffs seen on the left of the picture. Fig. 10 shows a similar ravine on the other side of Cadiroggio, which has been completed as far as the property of the brothers Severi extends. At the beginning this was similar in character to the ravine shown in Fig. 9.

11. Another method of escape is by a well and culvert. This is more usually adopted in cases where the bank is made up to a considerable height at the beginning, but otherwise the top of the well is built up gradually as the silting proceeds or else a slot is left in one side of it which is gradually blocked up. The object of this form of construction is to deliver the water below the bank with as little forward velocity as possible. One advantage of this form of escape is that, if the height of the bank has to be increased later on, it admits of this easily by merely adding another bank and well outlet behind the old one, the velocity of delivery being small the old bank is not damaged by scour. Where these banks are made up at once to any height above six feet or so, they are generally given a toe of

masonry as shown in Fig. 10, or of dry stone sausages of an ingenious form devised by Mr. Serrazanetti of Bologna. These consist of wire netting with the meshes formed by the wires being simply passed through the adjacent meshes without being twisted round them, so that it is exceedingly flexible. On a basis of such netting are formed rows of wire netting bags of similar construction, so that when these bags are filled with stones the whole forms a series of sausages connected together at the back. Figs. 11 and 12 show the well system as used at Castel Florentino where the banks are made up about 10 feet high to start with and afterwards added to, and Fig. 13 shows Mr. Serrazanetti's method, while Fig. 14 shows how such a bank as that in Fig. 13 can be raised by later additions.

12. One other form of escape remains, which is sometimes used on the completion of such a work as mentioned in paragraphs 9 and 10 to secure the safety of the whole, when the need for constant inspection has passed. It is, however, more usually adopted for a fall in the centre of a long bank, where this bank is made up to the full height at once. Fig. 15 shows the section of such a fall, which can be extended by adding to the number of wells as shown in the elevation above. I saw this form used on an estate near Ozzano, where a small stream had been giving much trouble in the foot-hills. It had scoured out a good deal under the foot of the hill and endangered the safety of the hill on which stood the house and farm, and it also wound about in the valley below, cutting up the land to a considerable extent. Here a bank 15 feet high was made with one of these falls in the centre (with three wells), on the line to which the stream was to be constrained. The stream rapidly silted up the reservoir so formed to within about 6 feet of the top of the bank, and when this was effected another bank and fall were made some distance upstream and side banks were made to the proposed stream line between the falls. There were thus left two silt tanks, one on either side of the new channel, and water was admitted to them by pipes from the new upper reservoir. The process was then continued, and when I saw it a third bank and fall were being made and the first reservoir silt tanks were nearly filled up. The whole work has only taken four or five years, and it is estimated that it will be completed in a couple more, when the valley will be entirely cultivated, the hillside safe, and the stream well under control. I may note that when the first fall was made pitching was placed on the downstream bed and banks. The action, however, was found to be so small from this form of fall that no pitching is being used on the later falls.

There were some excellent photographs of these works of which I was promised copies and for these I have delayed my report till now. As they have not yet come I have to send the report without them.

13. It will be noticed that in the preceding paragraph I have said that the filling up of the valley and controlling the stream has ensured the safety of the hillside. In every case of slipping hillsides which I have seen in Italy the cause is attributed to the action of the stream below in eroding the base, at all events in the original instance, and in all works of reclamation of such, the greatest stress is laid on the importance of fixing the base, while it is generally stated that work on the hillside itself would be useless without having the base fixed first. In ravines this is done by the "colmata" or silting up of the ravine bed from the bottom upwards by the methods above described. Where a torrent exists at the base, the torrent is first controlled, at least on the side where reclamation is to proceed, so that it can no longer scour the base of the hill. Then the hillside itself is attacked.

This fixing of the base is done either by merely controlling the torrent, or by silting below in the bed, or by elaborate walls and underground drains to dispose of the subsoil water as practised by the Government engineers at Bologna (I have been supplied with plans of these works but do not think it necessary to reproduce them here), or by dry stone wired walls on Mr. Serrazanetti's system. The reclamation above is effected mostly by cultivation only in combination with systematization of the drainage. The methods vary, but all agree on the prime importance of fixing the base.

14. I give in Fig. 16 a sketch plan of part of Mr. Serrazanetti's estate near Riolo. The ground was of the worst, a broken hillside consisting of the *débris* of landslips from the hill above and itself moving with every heavy shower of rain, as still does the land on either side of his estate.

His process was first to check the action of the torrent on the base of the hill by means of a spur, then to regulate the ravines by a series of banks with well outlets, and finally to make cross drains to carry off the rainfall quickly to the ravines. When I saw it, movement had ceased almost entirely on his land, though some of the walls where the cross drains cross the depressions were bent. This, however, matters little as the whole of his sustaining walls are of flexible dry stone wired walling. Flourishing crops of lucerne were growing all over this part of

the hill, while the land outside his fences was a scene of the wildest desolation, very similar to the landslip at Sultanagri near the Kathgodam railway station, only not quite so stony.

15. I have now described the Italian methods of improving their hillsides; there remains the most important question as to how far these can be applied to Indian conditions. There is no doubt that, to some extent, they are capable of application, though in India, except where similar work is already done as noted in Appendix C of Sir E. Buck's report on the Control and Utilization of Rivers and Drainage—the methods to be used must be of the more expensive types. Our rainfall is so much greater in intensity than that of Italy, where I could hear of nothing greater than 3 inches in 24 hours, that the simple methods in most cases employed there would not stand the strain of a single rainy season. Masonry works of some sort would be absolutely necessary for escaping purposes, though they need not always be very elaborate. Then our hillsides in the Himalayas and Siwaliks (of which alone I have any experience) are much steeper and less well covered with soil than the Apennines, and these Italian methods can only be successfully used where there is plenty of soil higher up the hills for use in silting up the ravines and inequalities. Where new land is needed for cultivation in the hills, it might perhaps be possible in some cases to adapt the Italian methods of terracing by water action, while in parts of the outer hills it would be possible to adapt them, though at a greatly increased cost owing to the heavier rainfall, to certain hillsides for the purpose of preventing slips and to lessen the amount of soil carried off by the hill streams. Under present conditions, however, I see little chance of their being of great use to us in any part of the hills.

16. Where I think, however, that these Italian methods could be most usefully adopted, is in the gradual reclamation of the ravines, which cover so large a tract of country along the borders of the Khadirs of many of our larger rivers in the plains. Masonry or tube escapes would be necessary even here, though they would be less expensive than in the hills, but it would be quite possible to dam the ravines at intervals and gradually wear down the higher portions, so that in the course of time the ravine tract of land could be terraced and sloped so as to bring the land again under cultivation. Careful surveys would first have to be made, and a definite plan of action laid down, and then a certain amount of supervision would be necessary to ensure the plan of action being carried out and to superintend the building of the required masonry works, the making and clearing of the ditches, and to see that the eroding action on the spurs was properly assisted by hand labour. But the ultimate reclamation of these ravine lands is quite within the bounds of possibility at no unreasonable cost.

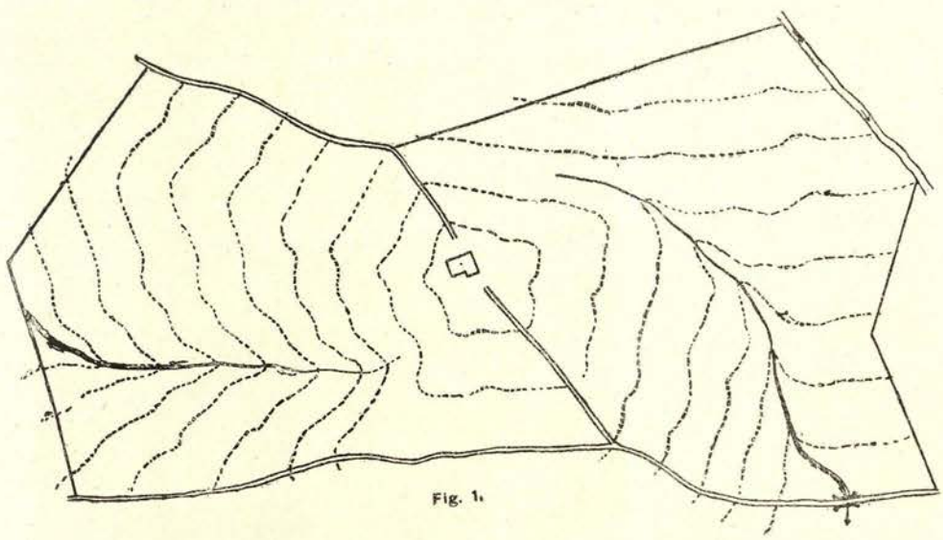


Fig. 1.

CONTOUR PLAN OF ESTATE.

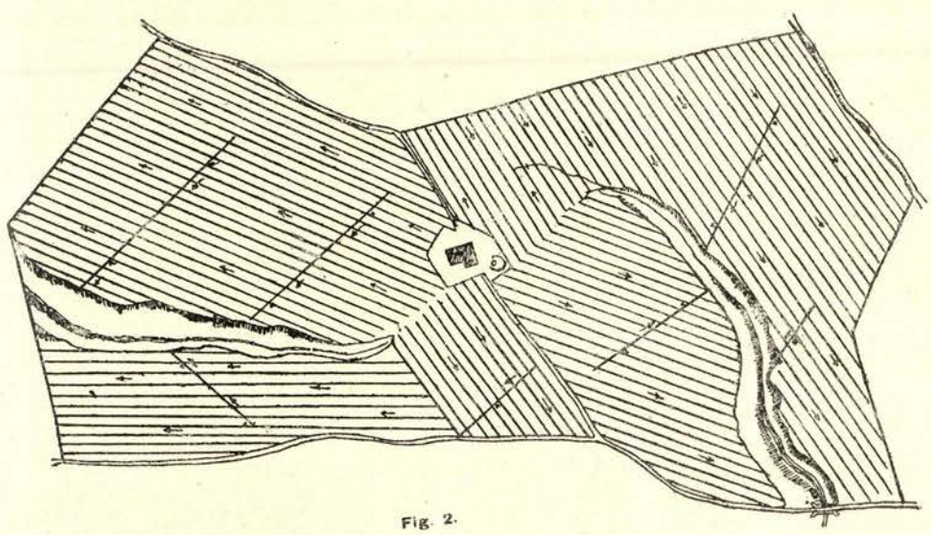


Fig. 2.

PLAN SHOWING CULTIVATION IN OLD STYLE.

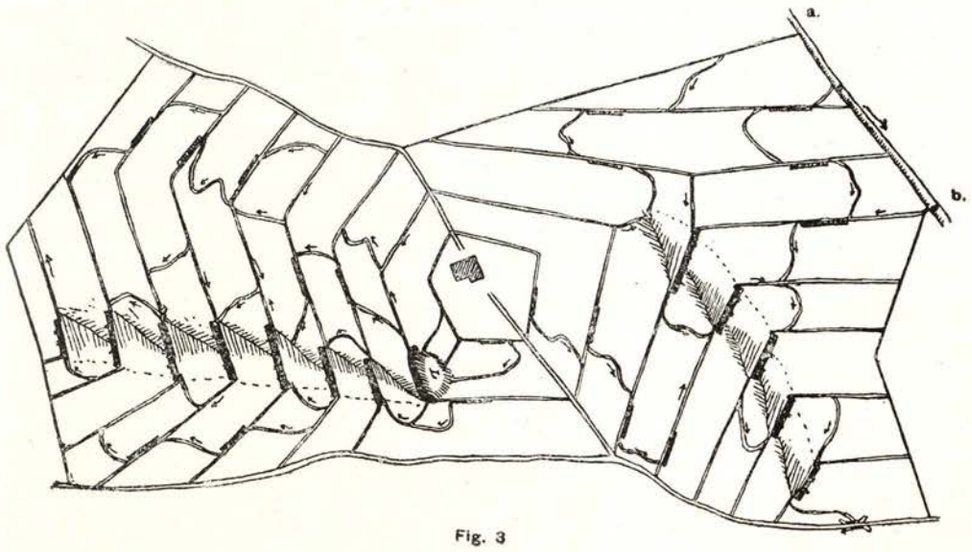


Fig. 3

PLAN SHOWING CONTOUR DRAINS AND BANKS.

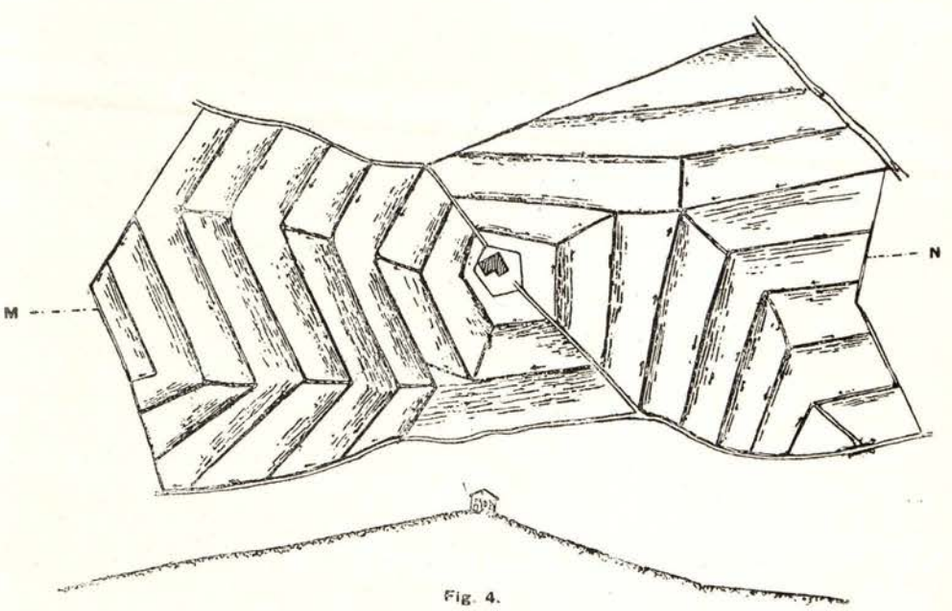


Fig. 4.

ESTATE WITH DRAINAGE SYSTEMATISED.

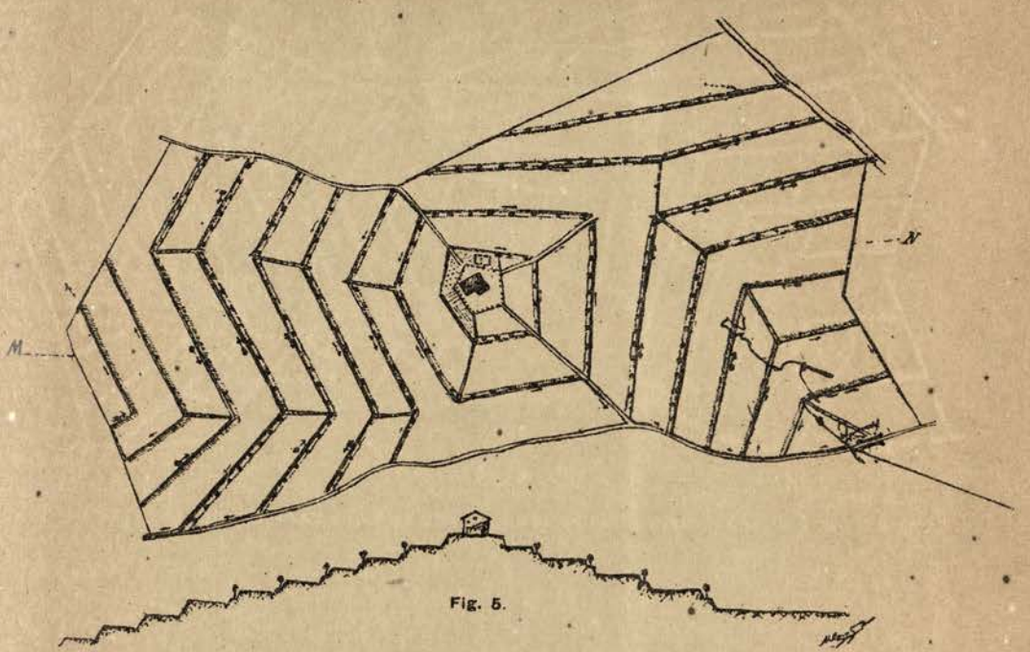


Fig. 5.

TERRACES COMPLETED.

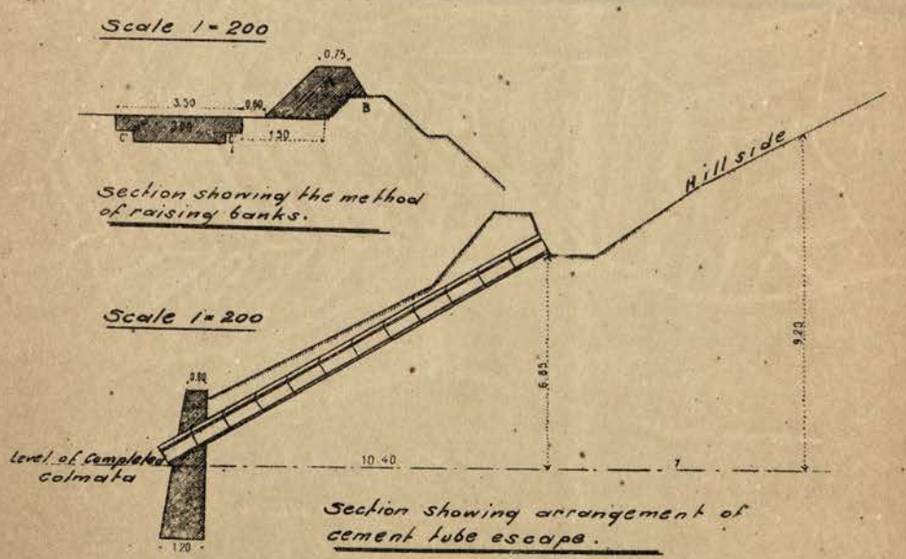


Fig. 6.

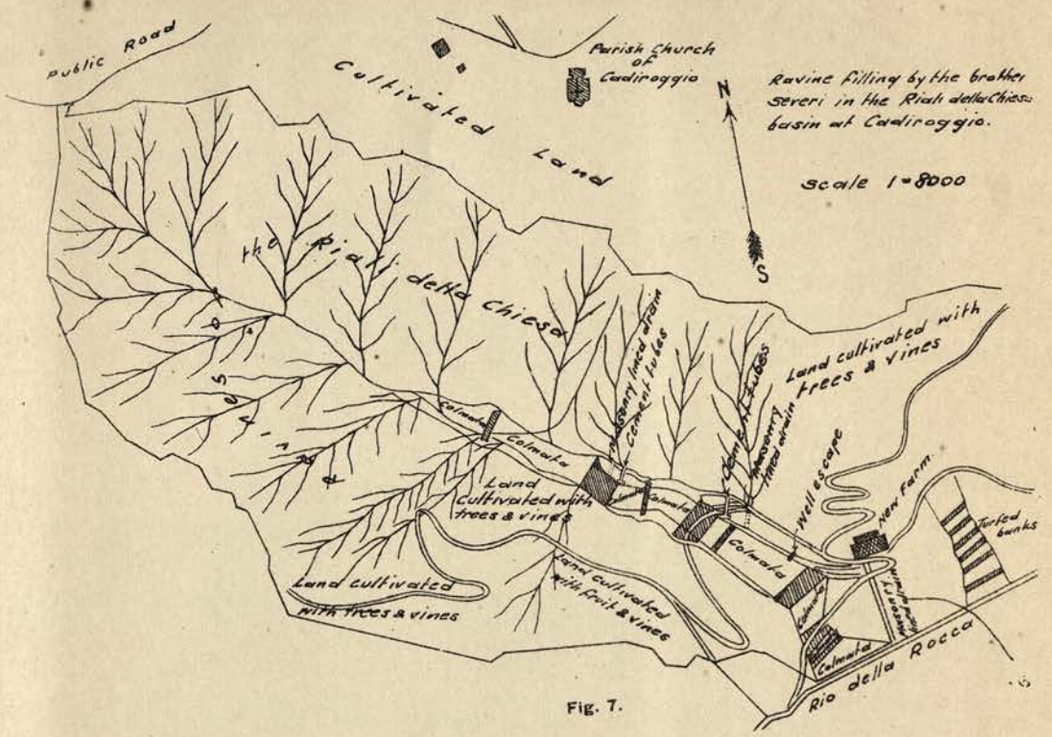
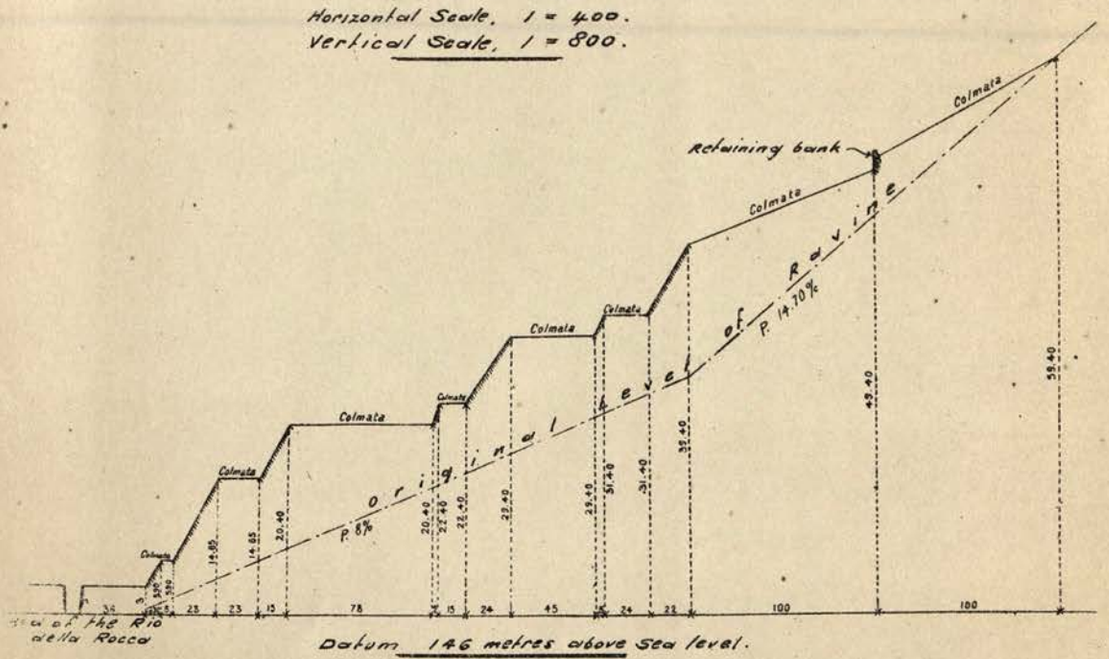


Fig. 7.

Longitudinal Section of the ravine filling in the Riali della Chiesa basin.

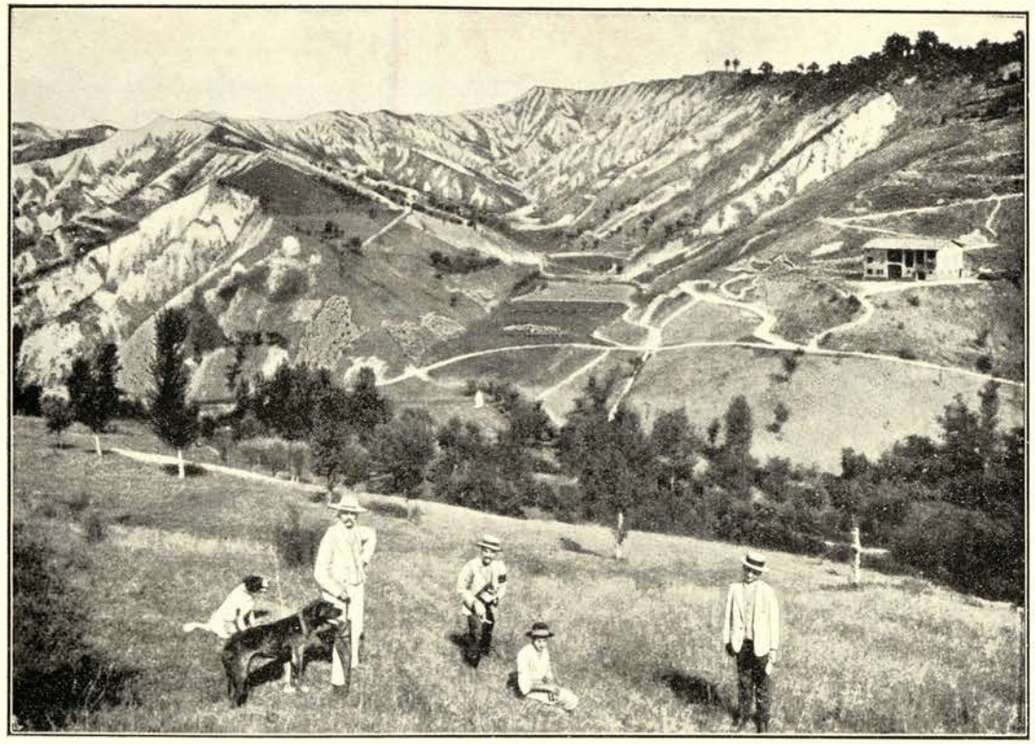
Horizontal Scale. 1 = 400.
Vertical Scale. 1 = 800.



Datum 146 metres above Sea level.

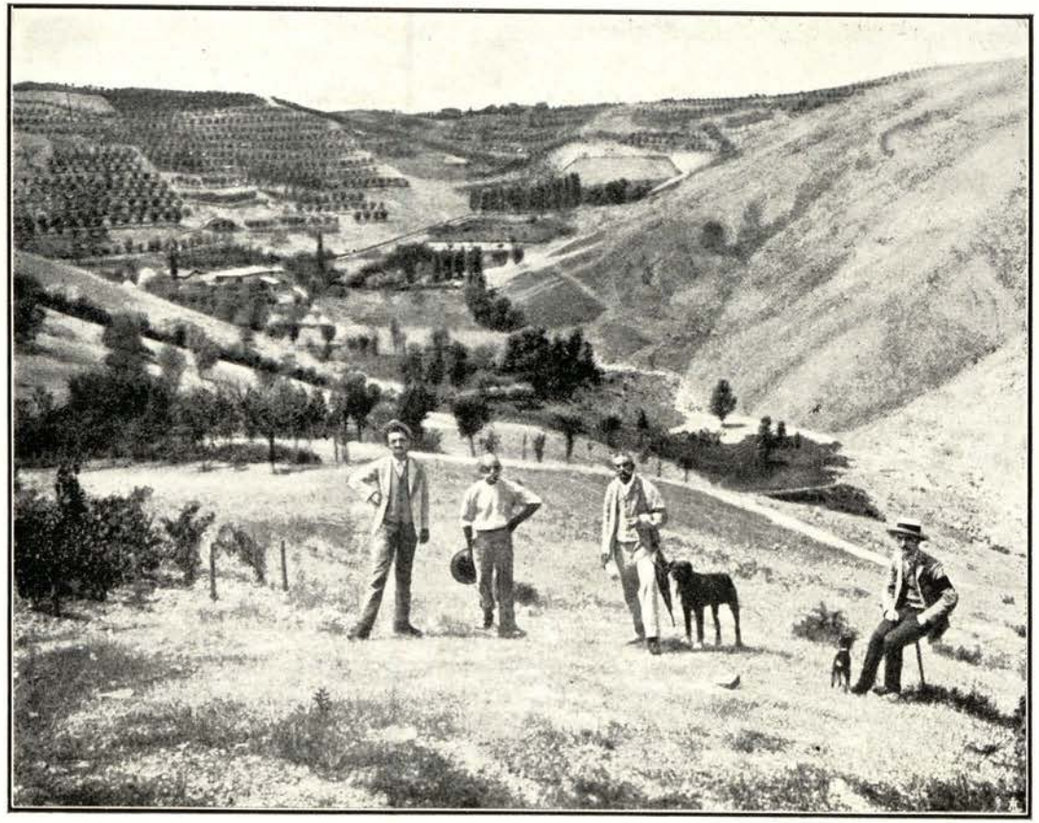
Fig. 8

FIGURE 9.



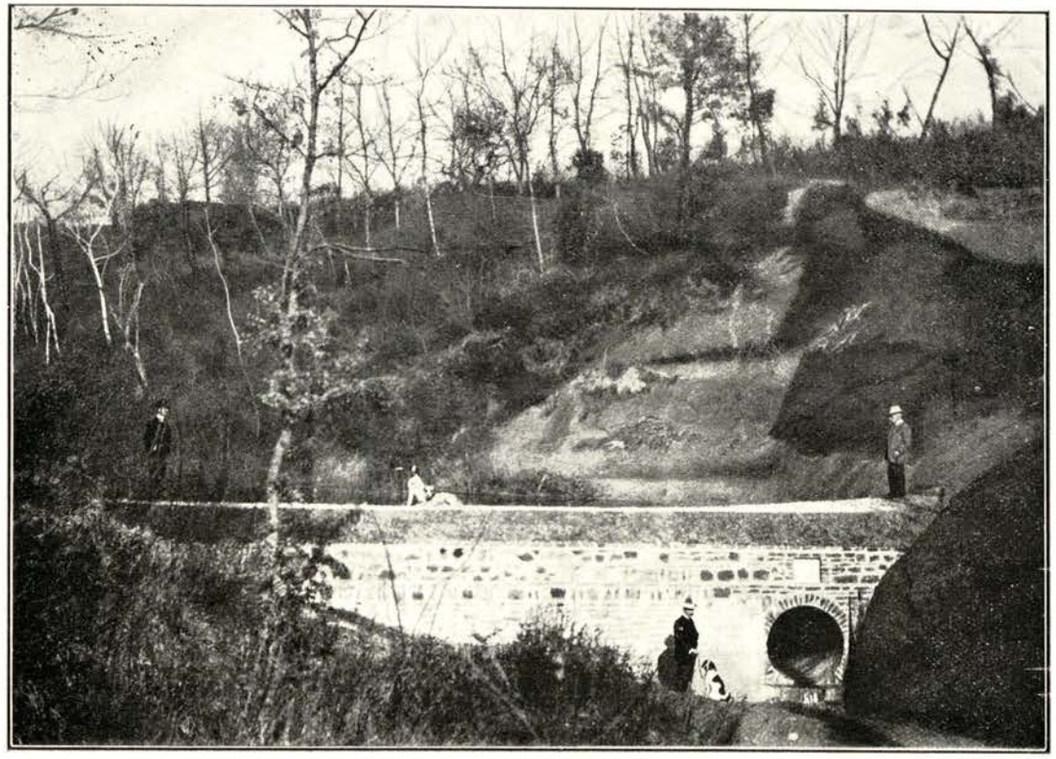
Basin of the Riala della Chiesa at Cadiroggio.

FIGURE 10.



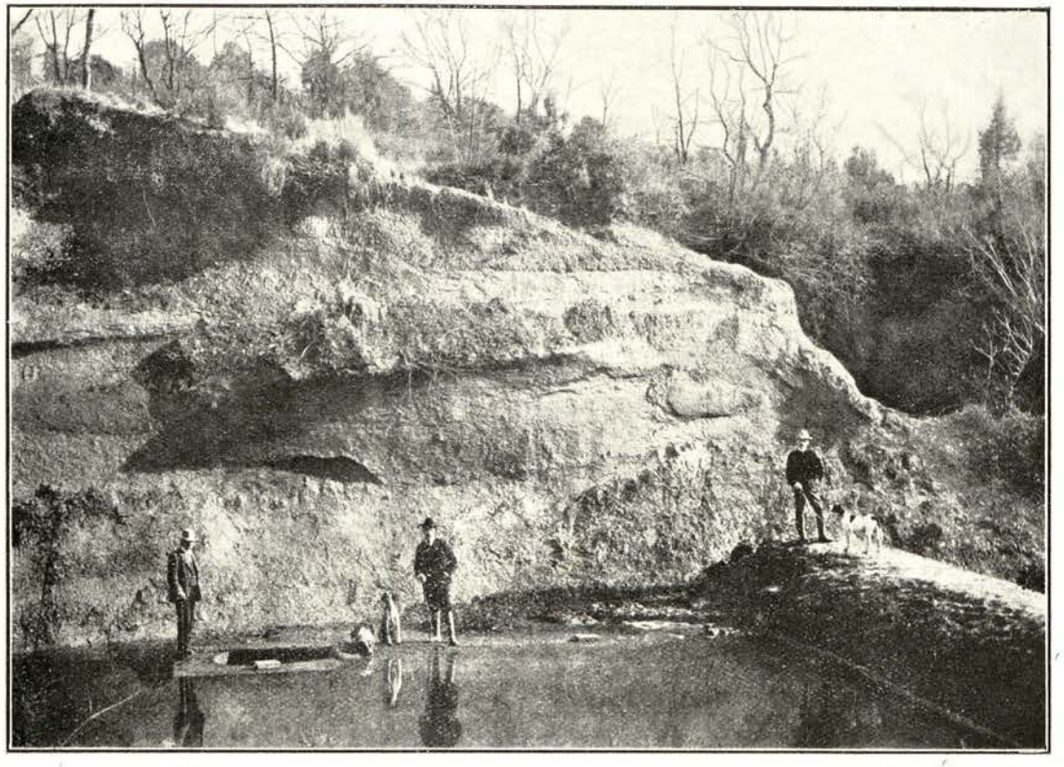
Basin of the Rio della Pietre at Cadiroggio.

FIGURE 11.



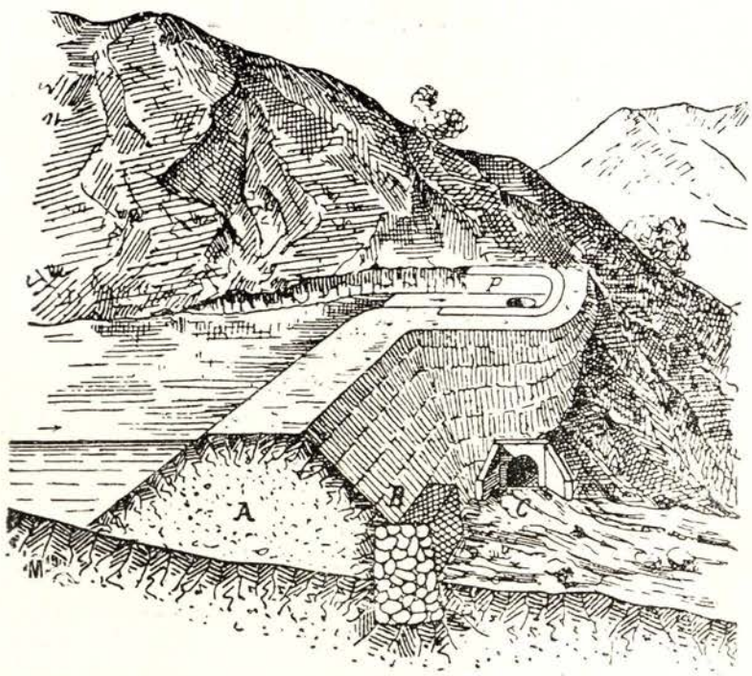
Well Escape at Castel Fiorentino in Italy.

FIGURE 12.



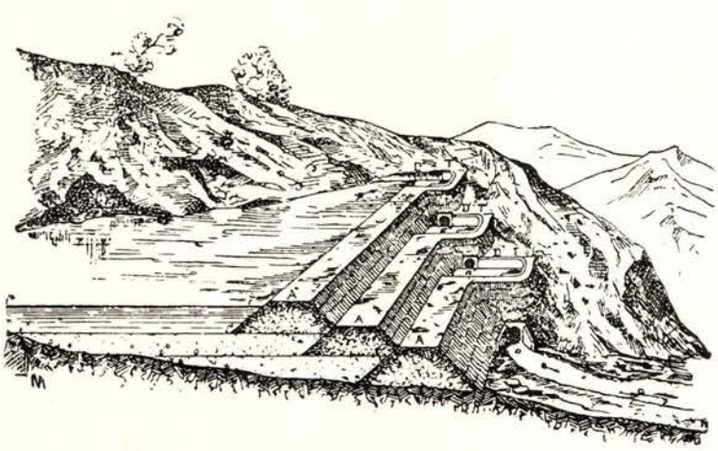
Well Escape at Castel Fiorentino, from above.

FIGURE 13.



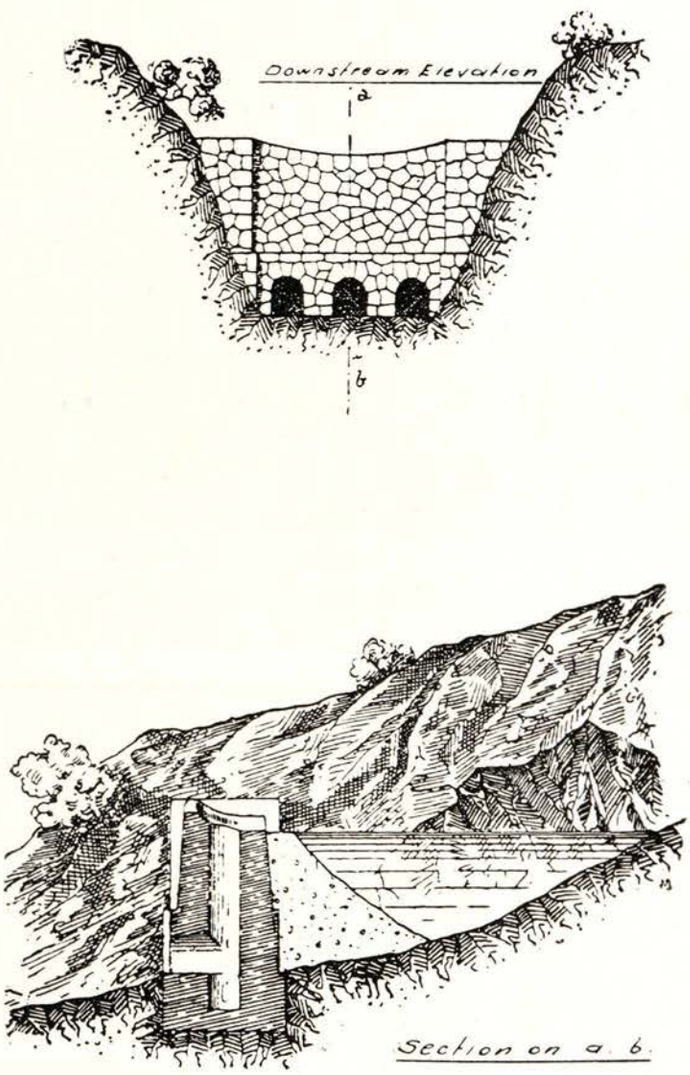
Serrazanetti bank and well escape.

FIGURE 14.



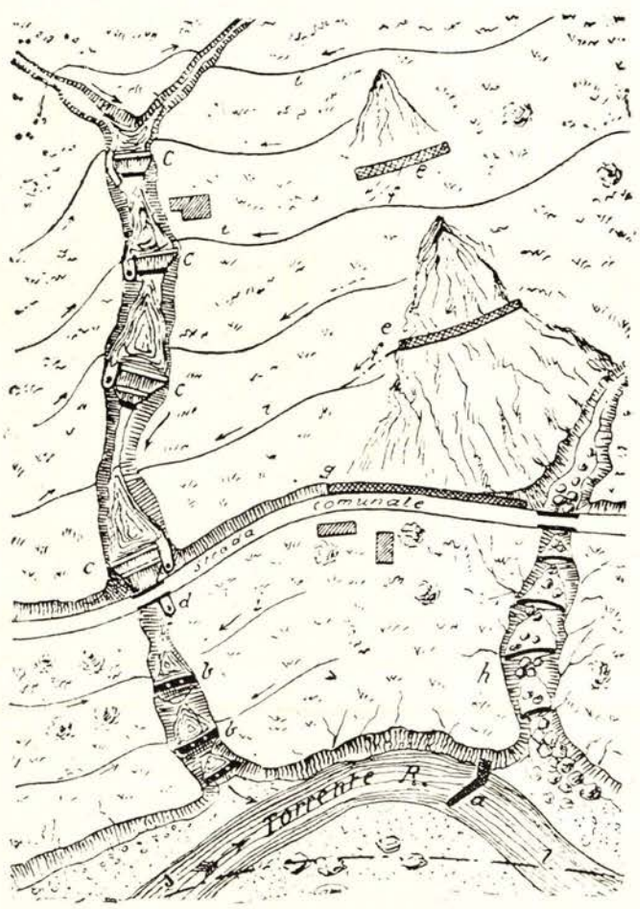
Method of raising the above.

FIGURE 15.



Fall for centre of banks.

FIGURE 16.



Sketch plan of Mr. Serrazanetti's estate near Riolo.

a. Spur in torrents.
b. Banks with falls.
c. Banks with well escapes.
d. Road bridge.
e. Sausage walls.
f. Subsoil drains.
g. Retaining walls of sausages.
h. Banks with wooden shoot escapes.
i. Contour drains.
j.—*l*. New line of torre

A SHORT NOTE ON THE SILTING UP OF THE BISTUPUR BHIL AT BERHAMPORE.

BY

MAJOR W. W. CLEMESHA, M.D., D.P.H., I.M.S.,

Sanitary Commissioner, Bengal.

THE work was taken up on the recommendation of the Drainage Committee of 1906-07.

2. The original project known as the Berhampore-Gobra Nallah Drainage Scheme, which the Drainage Committee recommended as one of the definite and practicable schemes for consideration, was modified by the Chief Engineer, and a fresh estimate amounting to Rs. 12,625 was sanctioned in Bengal Government No. 3888-I., dated 6th December 1909, for the works necessary for the scheme.

3. These works consisted of improving the Khagra Sluice and Channel through which the flood water of the Bhagirathi river is admitted into the Bhil, and remodelling the northern drainage cut through which the water, after depositing its silt in the Bhil, is drained off. The works were completed before the flood season of 1910.

4. The works in subsequent years consisted of clearing silt from the channel between the sluice and bhil and from the outfall channel (Northern Drainage Cut).

5. The following statement shows approximately the cubic contents of each part (the details are given below) before the flood season of 1910 and the quantity of silt deposited during the year :—

(i) The level of which is below 48·00 (which is the level of the floor of the Khagra sluice and of the head of the outfall channel). The area of this part is 15·4 acres.

(ii) The level of which is between 48·00 and 52·00. Area is 17·10 acres.

(iii) The level of which is between 52·00 and 56·00. Area is 18-37 acres.

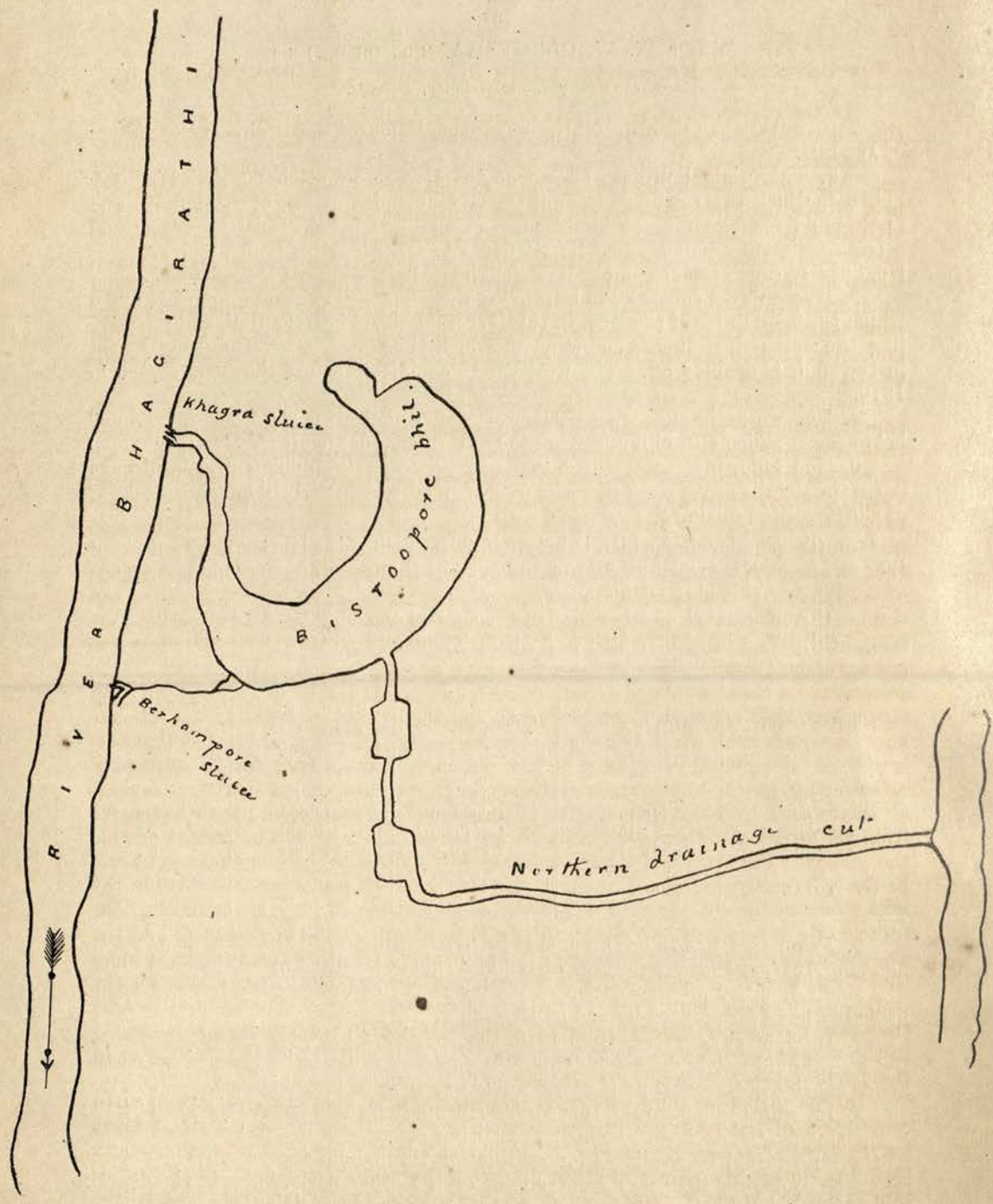
Number of part.	Area in acres.	Cubic contents.	Silt deposited during year.	Average depth of silt deposited in inches.
		Cubic feet.	Cubic feet.	
(i)	15·40	1,000,000	219,000	3·9
(ii)	17·10	4,277,000	469,000	7 5
(iii)	18·37	7,196,000	143,000	2 1
TOTAL ...	50·87	12,473,900	831,000	

6. From this it will be seen that in five years from 1910, that is, after the floods of 1914, the lowest portion of the bhil should be silted up to the level 48·00. The small quantity of water then remaining at the end of the flood season would probably have evaporated by end of December.

7. In eight or ten years from 1910, that is, about 1918, the lowest portion of the bhil should not be below 52·00, and it could then be easily drained when the floods subside in October and the land would be available for rabi crops.

8. It will probably take 15 years to silt up the whole area to the level 54·10; when this level has been reached, the silting operations might be discontinued, as the land would be available for cultivation throughout the year. The deposit on part (ii) during 1910 was greater than on the other parts, because the deposit must be heaviest at the tail of the channels leading from the sluices.

ROUGH SKETCH.



DRAINAGE AND SANITATION IN RURAL AREAS IN THE MADRAS PRESIDENCY.

BY

THE HON'BLE RAO BAHADUR M. RAMACHANDRA RAO, PANTULU GARU.

AT the previous sittings of this Conference, the subject of rural sanitation in this country has already attracted some attention. At the First All-India Sanitary Conference, Captain W. A. Justice, Sanitary Commissioner, Madras, read a paper on "Village Sanitation in the Madras Presidency." At the Second Conference held at Madras three papers were presented for discussion. The first was by the Hon'ble Khan Bahadur Syed Mahady Shah of Gogra, on "the Sanitation of small Towns and Villages." "Rural Sanitation in Bengal" was the theme of Babu Motilal Ghose of Calcutta. The third was a contribution on "Village Sanitation" by Syed Zahiruddin, Vice-Chairman of the District Board of Patna. The improvement of rural sanitation was also referred to in some of the papers read on rural water-supplies and other kindred matters, and the complicated character of the problem was sufficiently indicated in the discussion on the subject.

Captain Justice dealt with the subject under the three main heads of water-supply, drainage and conservancy. As regards the first, he expressed the opinion that wherever funds permitted, wells should be covered and provided with a pump, an elevated cistern, and taps, and that if an adequate number of wells were provided, "resort to rivers will be avoided so that rivers and streams would soon cease to be drinking water sources." The introduction of a regular system of drainage, he considered, offered insuperable difficulties on account of the scattered nature of the towns and villages and would also involve an immense expense beyond the means of any district. The existing side cuttings in rural areas, he stated, are adequate enough if kept clear of obstructions to free flow of water, and it was suggested that household sullage should be disposed of by drainage into the fields. In regard to conservancy, Captain Justice suggested experimental action. He proposed the selection of a town or village in each district for making the basis of operations. In the village thus selected, Captain Justice suggested the promulgation and observance of certain rules which he indicated in his paper. The first of these is that certain fixed sites should be selected on the outskirts of the village for the storage of all sweepings to which the owners of the houses in the village should carry for deposit all the rubbish from their backyards. The second is to compel all people to remove from the interior of their backyards all the cattle, which should be housed outside the village. The third is that no one should be permitted to perform offices of nature in the village streets, lanes, or open spaces. Some pieces of ground outside the village should be set apart to which people should resort for this purpose. The fourth rule he suggested was that all ruined dwellings should be removed, and the sites should be cleared and enclosed by the owners. He also expressed the opinion that there would be no difficulty in obtaining spaces beyond village limits for the storage of manure, housing of cattle and offices of nature. Finally, he thought the vexed question of village sanitation could be solved by a few simple rules issued to the village headmen on the conservancy of their village and the cleanliness of the dwelling-houses therein.

In his paper on rural sanitation in Bengal, Babu Motilal Ghose gave a vivid description of the past and present conditions of rural Bengal and went at great length into the causes of increase, in recent years, of malaria and other diseases in that Province. He also treated the subject of the improvement of village sanitation under the heads of rural drainage and rural water-supply, and his constructive suggestions are to be found at pages 520 and 521 of Vol. II. In the two other papers presented to the Conference a description is given of a village and a town in the United Provinces and in Behar and Orissa, and a perusal of them is enough to show that the problem of rural sanitation is more or less the same all over India.

2. I venture, therefore, to think that the subject of rural sanitation has not, as yet, received that consideration which it deserves, either in the elucidation of facts which have contributed to the existing state of things, or in the way of constructive criticism necessary for shaping the policy of Government with a view to accelerate sanitary progress in rural areas.

Activities of other Departments and their bearing on Sanitation.

I think that if progress in rural sanitation is desired, we should examine the question not merely from the point of view of the sanitarian, but probe into the matter with a view to find out to what extent the policy of the Government in other departments of work has resulted in the introduction of sanitary evils, without the removal of which it is impossible to make any headway. It therefore becomes important to examine some aspects of the work and the policy of Government in other departments, such as the department of Public Works, the department of Railways, the department of Land Revenue, and so on, each of which has to some extent contributed to the augmentation of sanitary evils in rural areas, however beneficial their work otherwise proved to be.

Public Health and Irrigation.

3. In the first place, it is perhaps necessary to point out that in the Madras Presidency the general sanitary condition of a district depends very much upon whether it is grown with wet or dry crops, and also upon the rainfall. The anicut and river systems of the Madras Presidency, as they exist at the present day, have practically come into existence since the British occupation of the country, and the irrigation dependent upon them has been gradually developed, so that at the present moment the irrigation revenue of the Madras Presidency is a valuable asset to the State. Excluding the Native States of Travancore and Cochin and the smaller States of Pudukota, Sandur and Bangenapalli which cover an area of 9,900 square miles, the total area of the Presidency amounts to 141,200 square miles, of which 19,200 miles are occupied by the agency tracts and 29,600 by the zamindary and proprietary estates. Of the remaining area amounting to 61·55 millions acres, about 36·53 millions are returned as cultivable, and the balance as forests, hills, etc. Of the cultivable area, about 83 per cent. is returned as being under occupation. The gross area irrigated from Government sources in the ryotwari and zamindary tracts is about 10 millions acres, just about a third of the occupied area and each of the five groups of districts has its peculiar systems of irrigation. The East Coast group, known as the Northern Circars, is the home of the great anicut systems of the Kistna and the Godavari rivers, irrigating the Godavari, Kistna and Guntur districts. Besides these anicut systems, the Nagavali and the Rushikulya projects irrigate large tracts of country in the Vizagapatam and the Ganjam districts. The Cauvery and Coleroon works irrigate the Tanjore and Trichinopoly districts and portions of the South Arcot district. There are smaller systems of irrigation in the districts of Nellore, Tinnevelly, Kurnool, Madura, and so on. The most pressing problem of sanitation is not probably the same in each group. Malaria in the Agency tracts, water-supply in the Deccan, require most urgent attention, while in the districts on the West Coast these problems are not so pressing. But the region where the problem of rural sanitation has become most acute is in the tracts irrigated under the great anicut and river systems of the Presidency. It is here that drainage, water-supply, the relief of congestion, conservancy and all other complicated problems of sanitation have become so pressing as to demand the immediate attention of the administrator and the expert.

A Typical Irrigated Area.

4. The comparative unhealthiness of the tract of country under wet cultivation does not admit of controversy. The cultivation of rice fields implies a residence in a quagmire for 6 months in the year, hardly conducive to physical well-being. As observed by Mr. J. C. Molony, the Madras Census Commissioner, this water-induced prosperity of the deltas is not an unmixed blessing. The people in these tracts are a prey to rheumatism, malaria, enlarged spleen, beri-beri, and various other kindred ills. To give a vivid idea of the state of things from the point of view of sanitation in these water-logged areas, I cannot do better than to invite the attention of the Conference to two reports on the sanitary condition of Ramachendrapuram Taluk, Godavari district. One is from the President of the Taluk Board, Peddapuram, a Provincial Officer of experience, and the other is from the notes of inspection by the Sanitary Commissioner, Madras, of some of the villages in that Taluk in 1910. In urging on the Government the absolute necessity of making the villages in the Ramachendrapuram Taluk habitable, the President states that in 76 out of 117 villages in the Taluk there is no vacant village site and that the existing occupied village site is overcrowded. Most of the villages are not connected with main roads, and being in the midst of low-lying land of alluvial clay, all under wet cultivation, they are stated to be inaccessible during the major portion of the year. He estimates the increase in the population to be as much as 75 per cent. since 1871 in most of the villages of that Taluk, and states that the people are so thickly packed in small houses that there is an inmate for every two square yards. No dry lands were available in 80 per cent. of the villages, nor close to the

existing village sites in others. The President goes on to state that amidst low paddy fields the villages look like so many islands in the irrigation season; that cultivation is carried on in the villages up to the very door of the houses and that most of the streets and lanes are miry and water-logged, so much so, that one cannot pass from one lane to another without great difficulty. This highly insanitary state of things continues throughout the irrigation season. The discomfort experienced is aggravated by the fact that for want of public latrines or suitable vacant ground for that purpose, corners of some of the lanes and bunds of tanks in the village are freely used for purposes of nature, particularly in the wet season. Speaking of communications, that officer says, that during the cultivation season and for a long time afterwards, all the cultivable portion round the villages becomes one wide expanse of cultivation, full of water everywhere. The existing paths and bandy tracks become water-logged and impassable, and all communication with adjacent villages is cut off, touring officers and villagers find it very difficult to pass from one village to another. They go by foot, for the use of carts is impossible, and the luggage is carried by coolies. In some of the villages there are no wells, the irrigation canals being the only drinking water sources. Wherever tanks exist, they have not been drained for generations as their beds are lower than the surrounding cultivated lands, and long accumulated silt and decayed vegetable matter have in many cases rendered the water unwholesome. Another item which greatly contributes to the insanitary condition of the villages is the want of cattle stands; village streets and tank-bunds being used as cattle stands. In concluding his interesting report the President stated that, rheumatism, malignant fevers, beri-beri and other diseases, so much prevalent in the delta areas, are due to the notoriously insanitary conditions created by the irrigation system.

5. A few extracts from the inspection report of the Sanitary Commissioner who saw 10 villages in the Taluk, presumably in consequence of the representation of the President to the Government, will also be of interest. This is what he says :—

"(1) *Voolapalli.*—Population 5,300, houses 1,060. The roads, streets and lanes of this village, which is a typical one, are almost impassable during the rains. During the wet weather it is impossible for wheeled traffic to move about in the village as the roads are softened by the rain and trodden to mire about 2 feet deep by the cattle. During my inspection I could only proceed by jumping from pial to pial with the aid of a pole. The wet fields extend to the very door of houses. Elephantiasis began in this village 3 or 4 years ago, there being from 50 or 100 cases in it at the time of the inspection. There is no latrine accommodation, the bank of the irrigation canal being used as a latrine. Subsoil water level is within one foot of the surface. Many wells 4 or 5 feet deep are invariably brackish due to pollution soakage. The drinking water is obtained from the irrigation canal above referred to."

"(2) *Kondukuduru.*—Population 5,000, houses 800. The chief street in the village is impassable and I could not walk through it without the help of a stick to keep me from slipping. It is in places, without exaggeration, knee-deep in soft mud and carts are brought through it with great difficulty. The soil in all these villages is alluvial clay without drainage. The lanes are tortuous, 3 to 4½ feet; expansion is much needed. The irrigation channel has been allowed to spread all over and has no turfed bund."

"(3) *Pandalapaka.*—Population 4,500, houses 850. There is a local fund road from the Cocanada canal into the village. It is raised about 2′ above the ground level and is dry. This is the only dry road in the village. The other streets are at subsoil water-level and consist of wet black stinking clay covered with green slime. All streets and lanes are of this description. It is impossible to go through any of the streets without wading ankle-deep in mud."

The Sanitary Commissioner's Conclusions.

6. After a detailed inspection of these villages the Sanitary Commissioner summarises the position as follows :—

"The difficulty which at once strikes one when considering the improvement of these village sites is the flatness of the country and the high subsoil water-level. During the rains the country is flooded not only by the rainfall but by the system of irrigation channels introducing water into an already flooded locality. Where villages exist, soil has been borrowed from the surrounding fields and used to raise the different house sites, build walls, make bricks, etc., etc. In this way most houses have adjoining them huge borrow-pits which are used as manure pits, rubbish of every description being swept into them; the pits are half or three-fourths full

of water from the high subsoil level. Drainage may be said to be almost impossible owing to the levels. There are a number of wells, masonry built, without platforms and drains, which are really useless, as any water taken from these wells is at once replaced by percolation from the surrounding subsoil water. Consequently they are all brackish from pollution and are used only for domestic purposes. There is little or no backyard accommodation as it is too expensive to make up the surrounding ground above subsoil level, and consequently the ground is under water during the rains. Where cow-sheds exist, these have been converted into habitations for agricultural coolies, the cattle either living among them or in the open, wherever they can find a dry spot. In other districts than the Kistna or Godavari, the fields are fairly dry and are used by the people for calls of nature, but in the Godavari district they are constantly under water and the people use any available dry ground such as banks of irrigation canals, roads and streets. It is not difficult after one has seen the condition of things during the wet weather to understand why cholera is so prevalent in the Kistna and Godavari districts. The irrigation channels are the chief source of drinking water-supply for the delta villages in the two districts mentioned above and they are largely polluted by the fouling of their banks. The streets and lanes of these villages are made of mud. In many places they have been encroached upon by the houses so that they have become tortuous and narrow, no drains exist, and in places it would appear as if the material of which the streets were made has been removed, hollows and low-lying parts being very common, full of water with no means provided for their drainage. The extent covered by houses is $\frac{1}{5}$th of the lowest allowed by the Board Standing Orders. Most of the houses are nothing but mud wall huts with earthen floors, damp and unhealthy, the floor level being but a few inches above the subsoil water-level. Rheumatism, respiratory diseases, fever, indigestion and bowel complaints, due to the insanitary condition in which the people live, are the principal causes of deaths among them."

7. These extracts from the reports of the Chief Administrative Officer of the division and of the Sanitary Commissioner are enough for my present purpose as showing the extremely unsatisfactory state of things in the deltaic portion of the Godavari district. But this description of the condition of things equally applies to the two districts of Kistna and Guntur irrigated by the Kistna delta system and to the districts of Tanjore and Trichinopoly within the ambit of the Cauvery delta, and the conditions are more or less similar to the above in the area commanded by the Beriyar project in the Madura district, and under the Rushikulya and the Nagavali projects, and also in the areas commanded by the various other major and minor systems of irrigation under the control of the Public Works Department.

The need for more effective Drainage in the Irrigated Tracts.

The present problems of rural sanitation in these irrigated tracts are the result of the introduction of large volumes of water into large tracts of the country without a proper perception of the sanitary needs of the villages in the areas commanded by the irrigation systems, and without taking the precautions which, if taken from time to time, might have greatly obviated the present difficulties. I shall refer to these a little later, but my present point is that, without improving the general system of the drainage of the country where the village site is almost on a level with the cultivated fields, it is impossible to improve the sanitation of these areas. Every sanitary improvement in these areas is dependent on a general drainage of the area under irrigation. That the drainage of these large irrigation systems is defective has been admitted by the Government more than once, and it would be unnecessary and out of place in this Conference to dilate further on the subject. I merely wish to indicate the general position in its bearing on sanitation. In Municipalities where water-supply has been introduced without proper drainage, loud complaints are heard that new and complicated sanitary problems have arisen for solution, so much so, that a demand has been made for the simultaneous introduction of water-supply and drainage schemes. In the case of these large irrigation systems, some of which have grown upon the old existing systems of irrigation in the country, the question of sanitation and drainage in the area commanded has unfortunately been hitherto treated as of secondary importance. The fact is that irrigation engineers and Revenue officers in the areas commanded by these projects were very anxious to develop irrigation and increase the revenue. The health and comfort of the persons who necessarily have to live in these areas, and the question of securing their sanitary well-being, does not seem to have been present to the minds of those responsible for the investigation or execution of these schemes. Only such arrangements as would be necessary for safeguarding the crops have been made. It will therefore follow that the improvement of the surroundings of these deltaic villages is absolutely hopeless unless the general system of drainage of the country commanded by the systems is improved. With the village site of most of the villages in the deltaic area on a level with the surrounding country and with the cultivation up to the very door of the houses in villages, the question of keeping the village site

ary for at least 6 months in the year, is an absolute impossibility under existing conditions. The point I wish to emphasize in this connection is, that the question of improvement of rural sanitation depends largely upon the policy of Government in regard to the expenditure of money in the drainage of the major systems of irrigation. In a discussion on rural sanitation it will obviously be out of place to dwell on the shortcomings of the department of Public Works in the matter of drainage in these large systems of irrigation. But I believe that if the Government is anxious to secure any improvement in rural sanitation, it would be necessary to examine the question of drainage of each system with a view to its bearing on the sanitary condition of the villages and localities commanded by the system. Such an enquiry is urgently needed, and the sooner it is undertaken the better. This must be a work of several years, but the problem of rural sanitation would, with such an enquiry, be placed on a sound footing.

Sanitation and the Revenue Department.

8. I shall now invite the attention of the Conference to the policy, or rather the want of a definite policy, in the Revenue Department and its general bearing on the question of sanitation. The chief sanitary evils in rural areas requiring attention are :—

(1) Want of room in villages for building purposes.
(2) Want of room for cattle.
(3) Want of open spaces in villages for performing offices of nature and for storing sweepings and rubbish.
(4) The absence of a good system of water-supply.
(5) Assignment of lands in close proximity to the village site for wet cultivation.

Before dealing with these five points, it will perhaps be necessary to point out that the sanitary environment of a village is very largely influenced by various circumstances which have to be recognised and provided for. Any sanitary remedies suggested or proposed which do not take into account the habits and modes of life of the rural population can never succeed in the long run. In a consideration of this matter it will therefore be necessary to examine the question with a view to provide such remedies as would minimize evils which cannot be entirely removed.

Congested Condition of the Irrigated Tracts.

In regard to the first of these points, *viz.*, the question of congestion, it must be admitted that the present state of things in the irrigated districts of the Madras Presidency is mainly due to a great increase of population coincident with the extension of cultivation. The rate of increase in the population and the rate of mortality are both lower in the dry districts of the Presidency compared with the districts classed as wet. The gramakanttam or the village site of the olden days provided for the requirements of the day ; up to 1875, the village site could be occupied by the villagers without the permission of a public official ; from 1875 to 1891 the permission of village officers was made compulsory, but in 1891 this power was taken away from them and vested in the Taluk Officers and Tasildars are now authorised to grant sites for building purposes to *bonâ fide* applicants in accordance with the scale fixed by Collectors at their discretion, and subject to the rules framed by the Board of Revenue. These rules lay down that the application for a house site should mention the purpose for which it is required, whether it is intended for a thatched house or a tiled one, or for putting up a cattle shed, and so on. The rules were conceived in a broad spirit of causing as little trouble to villagers as possible, but no attempt has been made to secure a proper development of the extensions in villages. In the Madras Presidency the village has not been surveyed in detail, with the result that it is not possible to make a plan of the available vacant site and the rules do not make it obligatory on Tasildars to assign village sites on any definite plan. The result has been a haphazard and irregular extension all round the villages. In rural areas the Tasildar is the primary authority dealing with this matter and Local Boards have no control over the grant of village sites. It must be admitted that the question of the orderly development of villages is somewhat complicated by social restrictions which have contributed to the irregular laying out of new extensions in villages, but it will be obvious that while so much insistence is being laid on town-planning and the development of new extensions on proper sanitary lines, it will be equally necessary that some steps should be taken, at least for the future, to secure a methodical extension of villages, by laying out the available village site according to some definite plan. It seems therefore necessary that in order to prevent further indiscriminate grants of village sites, the available village site should be properly laid out in a simple and ready manner, and the grant of sites be sanctioned with a view to secure some kind of method and order. As it is, the want of method has resulted in the very unsatisfactory condition of things

so graphically described by the Sanitary Commissioner in regard to the deltaic villages of the Ramachendrapuram Taluk, Godavari district. The description of the state of things in Ramachendrapuram in regard to congestion would apply more or less equally to the other areas irrigated by the anicut and river systems in the Madras Presidency. In the interests of the sanitary well-being of the teeming populations inhabiting the irrigated tracts it will be necessary to undertake a periodical examination at the end of each census, of the extent to which extension of village sites would be necessary. Collectors have been empowered, where the existing village site does not suffice for the needs of the resident villagers, to extend the site by transfer of assessed lands to poramboke or by the addition of other description of poramboke. In cases where it is necessary to acquire land for extension of the village site, they are empowered to act on their own responsibility, where the extent involved is not more than 5 acres or the expenditure not more than Rs. 250. In other cases they have to obtain the orders of the Board and the Government. Once in a way an energetic District Officer who could foresee future difficulties gave effect to these instructions, but the orders have practically remained a dead letter in all these tracts. Had the question of the necessity of the extension of village site been examined from time to time, the present situation could not have arisen. As it is, land which could have been secured at a moderate price, had action been taken in time, has now become very valuable. In the Ramachendrapuram Taluk the land required for extension of the village site was acquired at a cost of Rs. 500 to Rs. 1,000 an acre, while if it had been acquired in time, it would have cost not more than a tenth of the present price. An adequate provision for cattle is equally important in any scheme for the improvement of rural sanitation. Even here, there is considerable room for complaint.

Accommodation for Cattle.

The presence of a large number of cattle in an agricultural village is one of the features of rural life in the Madras Presidency. The only question for consideration is whether in the interests of the health of the inhabitants it is feasible or necessary to house the cattle elsewhere than in the village site. There can be no question of keeping the village site clean and in a sanitary condition, when the large numbers of cattle are accommodated in the houses of the cultivators for want of even standing ground outside the village. The present state of things is, that the whole country round each village up to the very doors of houses is assigned on patta for wet cultivation, with the result that during the whole cultivation season the cattle are practically confined to the inhabited village site for nearly 6 months in the year. They have no place to roam about as the whole surrounding country is under water, and with growing crops. I have not been able to ascertain accurately whether at the time of each settlement the requirements of each village, from the point of view either of grazing grounds or cattle stands, has ever been considered in the Madras Presidency. The only recent instance I have come across where this has been done with reference to each village was in regard to the re-settlement of the Chingulput district, where the Settlement Officer examined the question with reference to the requirements of each individual village in regard to pasture grounds and cattle stands. Unless some such plan is adopted the insanitary condition of villages due to the presence of large numbers of cattle can never be remedied. The indiscriminate sale of communal lands and cattle stands and tank beds has contributed greatly to the existing state of things. The Government of Madras have recently issued orders, at least in 3 of the deltaic districts, prohibiting the sale of communal lands such as cattle stands, grazing grounds, etc., in the vicinity of villages (*vide* G. O. No. 598-Revenue, dated 28th February 1913). But by the time this order was issued most of the mischief had been already done. It seems, therefore, essential, from a sanitary point of view, that an enquiry should be undertaken whether in respect of each village in these irrigated tracts there is enough of standing room for cattle and, in case it is found that there is not enough room, to undertake extension of village sites in localities where it is urgently needed. The Sanitary Commissioner has stated that in most of the villages, the village streets and tank bunds are used as cattle stands for nearly 6 months in the year, much to the detriment of the sanitation of the villages. This is one of the greatest difficulties in the way of improvement of rural sanitation.

Open Spaces and Latrines.

10. The want of open spaces and latrines for performing offices of nature in rural areas has become a serious menace to the people. Tank and channel bunds from which drinking water is taken are often used for purposes of nature. The provision of latrines of a pattern approved by the Sanitary authorities is a superfluity in villages. They do not generally serve their purpose for want of supervision. The cheapest and probably the best from the point of view of the people,

to provide topes and open spaces which should be planted with shrubs and trees for affording cover. For a good long time this will be enough till the village develops into a town.

Rural Water-Supply.

11. As regards the improvement of water-supply in rural areas, it will be admitted that the main problem of a good water-supply can be solved only by tapping wherever possible the underground springs on a large scale, or conserving surface water wherever the conditions are favourable. In this country no record is maintained either by the Public Works Department or by the Sanitary Department of the extent to which subterranean water-supplies are available. I understand that in the last year or two 3 or 4 District Boards have employed boring maistries on a salary of Rs. 25 each, to work a boring apparatus useful only up to 100 feet. These men are employed for trial borings for Local Fund wells.

What is, however, urgently required, is a complete survey in each district at the cost of the State of the subterranean water-supplies, and the preparations of charts and records showing the course of the underground springs available. In areas where there are no wells and where there is scarcity of drinking water, subterranean springs should be tapped by a series of borings for every one or two square miles, and the results made available both to the people and to the local authorities. It is only in this way that the supply of good drinking water can be secured for the people. The work may appear stupendous at first sight, but on a careful consideration I think it will not be impracticable—it will have to spread over a large number of years. Attention may be invited to the work that is being done in America in this direction. For several years the Government of the United States have organised a systematic survey of the underground water in the whole country, and most interesting monographs have been periodically published by the Department of the Interior. A perusal of these will show the magnitude of the work that has been done and is in progress. Most valuable data as regards the sources, distribution, quality of the underground waters, have been collected by a regular survey by suitable borings at short distances, and detailed information as regards wells, the quality and quantity obtainable, depth at which it can be reached, and the height of water available in each region, is published for the use of those interested in well sinking. The magnificent record of deep well drilling in the United States shows that difficulties which appear insurmountable have been overcome in the quest of underground supplies. A thorough investigation of the sources of underground water-supplies is also needed in this country and practically nothing has been done so far in this direction. In the Madras Presidency, a Pumping and Boring department was organized in 1906 mainly in the interests of irrigation, and by a recent order of the Government of Madras, the activities of the Department have been confined to boring operations necessary for agricultural purposes. The success of this Department as affording a stimulus to the ryots to undertake boring for agricultural purposes is now admitted, and I have no doubt that a similar organization for the extension of wells for drinking purposes is urgently called for. The District Boards might be enabled to extend their work in this direction under the general control of the Sanitary Engineer. Systematic work in this direction is the only solution of the problem of rural water-supplies.

A Dry Belt of Land around the Village.

12. The last point to be noted in this connection is the question relating to the assignment of land for wet cultivation in close vicinity to the villages. The evils of the existing system are so patent that it is unnecessary to recapitulate them. The Government of Madras have now taken steps to prohibit the assignment of lands for wet cultivation within 50 yards of the village site (G. O. No. 854-Revenue, dated 25th March 1908, and G. O. No. 1568, dated 19th June 1911, Appendix C), but by the time the order was passed, most of the lands had already been assigned; in fact, the Government's action was due to representations that the policy of Government in permitting the assignment of lands without securing a belt of dry land round the village site has resulted in the creation of a most difficult situation. The order refers to future assignments: it is impossible without an expenditure of great amount of money to rectify the past. It seems however necessary that some action should be taken in this matter.

Borrow-Pits along Railway Lines.

13. The construction of Railways is another important factor and its bearing on rural sanitation has to be clearly recognised. It is natural for a Railway company to keep the cost of a line as low as possible, and with that view to make borrow-pits all over and to construct the minimum number of culverts for draining the country without regard to the health and comfort of the neighbouring inhabitants. Neither the owners of the neighbouring properties, nor the local authorities, are able to influ-

ence railway administrations in this country to do all that is necessary from the point of view of sanitation. Large and deep pits made in the midst or in the vicinity of populous towns and villages are left unfilled for years. A cursory inspection of a railway line as it passes through any populated part of the country will bear out this fact. Great injury has been done to the rural population in this country by these pits being left unfilled, and the state of things in Madras and in other Provinces is more or less the same. At present there is nothing to prevent railway administrations from digging borrow-pits within the limits of inhabited villages, rural towns, and municipalities, and any action to compel the railway authorities under the provisions of the Municipal Act has not been effective for various reasons.

A statutory prohibition under the Indian Railways Act against making borrow-pits within a certain distance of a town or village, or enjoining that the pits made should be filled up within a reasonable time, is absolutely necessary. There are no such rules at present in the Madras Presidency. Local public opinion is not strong enough to compel the railway administrations to take action, and the limited powers given to local authorities under sections 11 and 12 of the Indian Railways Act (IX of 1890) have not been effective. The wide powers enjoyed by the Railway administrations in India are taken from the English Act, but in England, apart from public opinion, which is more insistent than in this country, there are many parliamentary safeguards for publication and discussion of the proposals for construction and generally for securing the health of the inhabitants of the affected localities. In this country for a long time to come the initiative in these matters must come from the Government.

Finance.

14. I now refer to the subject of finance. Captain Justice says that the first and the foremost obstacles to rural sanitation is the lack of funds, and that general directions for the improvement of sanitation are sure to be disregarded and in fact would be beyond the financial resources of most districts. This is in the main true. I have endeavoured to show in the above paragraphs the extent to which the activities of other departments of Government have contributed to the present problem of rural sanitation. Is it right then that the Local Boards should take the whole blame and should take the financial responsibility for bringing about the desired improvements ? I contend that in the preparation of a scheme for irrigation, due provision ought to be made for some initial expenditure on sanitation and communications in regard to the villages in the tract of country affected by the project. The present rules for the preparation of irrigation projects are contained in Articles 736 to 748 of the Public Works Code and the only direction with reference to drainage will be found in Article 744, where a direction is given that the effect of the works on the natural drainage of the country should be carefully considered, and the precautions taken to prevent injury by inundations or percolations should be explained before the project is sanctioned. The result is that in large irrigation projects prepared in this Presidency no heed has been paid to the effects of the introduction of irrigation on the general health and sanitation of those who have to live in the areas affected. I believe that where villages will be prejudicially affected from a sanitary point of view by the introduction of wet cultivation all round where none existed before, such expenditure as is necessary to counteract the evil effects, natural and incidental to the change, should be debited to the irrigation project. This would include the cost, if necessary, of raising the level of the village site above the level of the surrounding irrigated area. If the drinking water-supply in the project area is prejudicially affected, it will be equally reasonable to debit to the scheme the cost of making suitable provision in this respect. If the introduction of irrigation into a particular tract floods the country and destroys communications formerly existing, it would not be out of place also to make suitable provision in this respect. Suitable building ground for those who must necessarily flock into the area must be considered also as a legitimate charge on the profits accruing from the project. This has not been done hitherto, and I have been informed that even in projects recently investigated, no provision has been made for any of these purposes. The present practice is that all sanitary works, the construction of roads and the provision for extension of dwelling sites, ordinarily devolve on Local Boards. This is neither just nor fair to the inhabitants of the affected area, or to the local authorities. The removal of the most complicated sanitary evils, created by the introduction of the irrigation system, is certainly beyond the means of the local authorities in the country and is not a legitimate charge on their resources. The major irrigation systems financed mostly by borrowed capital have given very handsome returns. Some are paying as much as 21 per cent. on the capital outlay. This handsome income has been derived at the expense of the health, comfort, and lives of the inhabitants of these areas. It seems, therefore, that the first and most important step is to undertake an examination of what is necessary in the cause of

sanitation in these areas, the most thickly populated tracts in the whole country, and to debit the cost of the necessary improvements to each project. Local Boards would then be enabled to perform their legitimate function. Viewed in this light, the question of finance should not be an insuperable difficulty, and I trust that this Conference will strenuously press this matter on the attention of the financial advisers of the Government.

Organization for the Promotion of Sanitation.

15. Finally, there is the important question of organization. In the first place, there is no doubt that the department of Sanitation has been too long in the coming. Now that sanitation is occupying so much attention from responsible authorities, it is time the department was properly organized in each province. I think the first step towards completing the machinery is the creation of a Chief Engineer for sanitation in all major provinces. Sanitary engineering has become one of the most important branches of the administration and is in need of specialization in India. Apart from this, the history of rural sanitation during the last 30 or 40 years is enough to show there are not in the present machinery of Government any checks and safeguards so necessary in the interests of rural sanitation, to counteract or moderate the somewhat one-sided zeal of irrigation engineers. The sanitary side of every irrigation project must not be considered in the haphazard way in which it has hitherto been done. The only authorities who could stand up for sanitation are the local bodies, and they have no effective voice at present in shaping the discussions of Government on matters in which so much reliance is placed on the views of experts. There should be some officer with a direct voice in the councils of Government in sanitary matters, and who could give the necessary impetus to sanitary work. The functions of District Boards will have to be enlarged in various ways on the lines of powers possessed by rural sanitary authorities in England for the promotion of sanitation. Lastly, some kind of village organization will have to be provided for carrying out sanitary regulations. Captain Justice seems to be of opinion that the village Munsiff and the Tasildar can do all that is necessary. I do not share this view. I think the co-operation of the people in the village will have to be sought and this can only be done by an organization in which the villagers can have some voice as well as some duties. Neither the village Munsiff nor the Tasildar can do anything without the active co-operation of the people.

In conclusion, I would briefly summarise my proposals.

Summary of Proposals.

I would suggest that the attention of the Local Governments and administrations be invited to the following points:—

(1) That an enquiry be undertaken in each province as to whether in the interests of rural sanitation there is need for more effective drainage in the areas commanded by the irrigation systems of each province.

(2) That, with a view to remove the very serious sanitary defects in these areas which have resulted from the introduction of irrigation, such urgent sanitary measures as may be found necessary for the removal of these evils be undertaken, the cost of such measures being debited to the system from which the defects originated.

(3) That in regard to pending and future projects of irrigation, the desirability of making provision for such initial expenditure on the sanitation in the area commanded by the project as may be found necessary on account of changes consequent on the introduction of irrigation, be also considered.

(4) That after each census a periodical examination be undertaken in each province as regards the necessity for extension of village sites in the congested villages, for habitations, for standing ground for cattle, and for other communal purposes, in all areas commanded by the irrigation projects and also in areas where the results of census indicates a substantial increase in population.

(5) That in order to secure the proper laying out of villages and also of future extensions in villages, the available village site in each congested village should be properly laid out wherever necessary and that early steps should be taken in all project areas to relieve the existing congestion.

(6) That cheap model villages be laid out on sanitary principles in the vicinity of the chief town in every taluk in the district.

(7) That the desirability of framing suitable rules prohibiting the railway companies and administrations from making borrow-pits within a specified distance of a town or a village be considered, and that in the case of existing borrow-pits the Railway companies and administrations be instructed to take early steps for filling up such of them as are in the vicinity of a town or a village.

(8) That with a view to provide facilities for people for digging wells in the rural tracts, a systematic survey of underground water-supplies be undertaken, and that grants be also made to the Local Boards in each province for the purchase

and maintenance of a set of boring tools and apparatus, and that they be encouraged to render all necessary help to those interested in digging wells by undertaking all preliminary testing for the sinking of wells and by the publication of all available information in regard to underground water-supplies.

(9) That in the irrigated tracts where the people are dependent for drinking water on tanks fed by the irrigation channels, separate provision be made for water for cattle by the construction of separate tanks or ponds wherever necessary, and that in the dry tracts steps be taken for the conservancy of water, both for men and cattle, separately, wherever necessary and possible.

(10) That the Department of Sanitary Engineering in each province be placed on a more satisfactory basis, and steps be taken to bring into existence in each district Boards of Sanitation, or that the present powers of the District Boards in regard to rural sanitation be widened.

(11) That the co-operation of the people in the cause of rural sanitation be secured by bringing into existence some organization in each village for the purpose, and steps be taken to examine the question of organization from this point of view.

RURAL SANITATION IN THE UNITED PROVINCES OF AGRA AND OUDH.

BY

THE HON'BLE RAI SRI RAM BAHADUR, C.I.E., M.A., B.L.

IN this paper I propose to deal with the subject of rural sanitation so far as it concerns the purely rural areas in the United Provinces of Agra and Oudh, excluding from consideration Municipalities, "notified areas" and "town areas."

The views which I venture to place before this Conference and the observations which I make for its consideration are not those of an expert nor of a professional man, but they are based on knowledge obtained and experience gained in the course of every day life.

That the sanitation of these Provinces does require the closest attention of the Government is not open to any doubt. The deplorable condition of the health of these provinces is thus described by the Local Government in the opening paragraph of its review of the Sanitary Commissioner's report for the year 1911.

"The report of the Sanitary Commissioner for the year under review is melancholy reading. The birth-rate rose from 41 per mille to 43·84, but the death-rate rose still higher, *viz.*, from 38·67 to 44·95. The latter figure being calculated on the reduced population of the census of 1911, somewhat over-estimates the relative mortality of the year compared with that of its predecessors. But the death-rate, even when the necessary deduction on this account has been made, is still higher than the quinquennial average."

It was not the first time that a remark of this kind emanated from the Local Government. The two first years of the quinquennium (1907-1911) show a similar gloomy feature. In the review for 1907 the first paragraph begins with these sentences:—

"The statistics given in the report afford food for very serious reflection and indicate a state of affairs calling for the anxious consideration of the Government and the local authorities. The birth-rate is below and the death-rate above the normal."

Observations of a similar nature were made by the Local Government in the review on the report for the year following, *viz.*, 1908. The first paragraph runs as follows:—

"The vital statistics of the year 1908 are overshadowed by the deplorable epidemic of malarial fever which swept through the greater portion of the provinces, between August and December. The previous year had been one marked by a high death-rate and a low birth-rate and these features were accentuated in 1908. The mortality was the highest that has ever been recorded, about one-twenty-fifth of the whole population perished from causes classed as "fever," whilst the deaths from all causes amounted to one-twentieth of the population. In 1907 a high death-rate was due to plague which was most fatal in the towns of the province, whilst in 1908 the excessive mortality was due to fever and the fever death-rate was considerably higher in rural than in urban areas."

The above observations receive a melancholy confirmation from the results of the recent census, held in 1911.

Of the major provinces of India, the United Provinces (along with the Punjab) have the unenviable distinction of showing a decrease in population, instead of the usual increase generally found in other Indian provinces and the Western countries. This decrease was to the extent of 510,233.

The subjoined table shows the increases in other Indian provinces (except the Punjab) and the decrease in our province, as compared with the figures of the previous census; *viz.*, of 1901.

Serial No.	Name of Provinces.	Population according to the census of 1911.	Population according to the census of 1901.	Increase or Decrease.
1	Burma	12,115,217	10,490,624	1,624,593 (Increase)
2	Eastern Bengal and Assam ...	34,018,527	30,510,344	3,508,183 (Increase)
3	Bengal	52,668,269	50,715,794	1,952,475 (Increase)
4	Bombay	19,672,642	18,559,650	1,112,992 (Increase)
5	Central Provinces and Berar ...	13,916,308	11,971,452	1,944,856 (Increase)
6	Madras	41,405,404	38,229,654	3,175,750 (Increase)
7	United Provinces of Agra & Oudh	47,182,044	47,692,277	510,233 (Decrease)

The above remarks relating to excessive mortality apply equally to urban and rural populations of these provinces. But there is a difference in the treatment of the two classes by the Government. All possible measures are being taken to improve the sanitation of urban areas. Very large amounts are being spent annually to improve and reform urban sanitation. These expenses are no doubt borne partially from the incomes raised by the Municipalities themselves, but substantial grants are made by the Local Government towards the cost and the Central Government helps them with large subventions given for the purpose. As to the grants made by the Government of India for urban and rural sanitation, the incidents of the present financial year may be mentioned by way of illustration. In the allotments announced on the occasion of the introduction of the Budget in the Imperial Council in March last, no less than 27½ lakhs were given to these provinces as non-recurring grant, to be spent on urban sanitation. A recurring grant of six lakhs was also announced which was to be spent on urban and village sanitation both, but no specification of the shares in which it was to be spent was given. It was also said that the Local Government would devote on rural sanitation a portion of the cesses which were set free.

According to the Census of 1911, the number of inhabitants in the rural areas is 42,371,430, whilst that of urban areas is 4,810,614, the proportion, therefore, of the rural population to urban is in the ratio of nearly 9 to 1.

Further, we must consider that the classes connected with land reside mostly in rural tracts. It is they who pay the Land revenue, Rates and Cesses to the Imperial and Provincial Exchequers. I may be allowed to say without exaggeration that in India the classes directly and indirectly dependent on agriculture virtually form the nation; that diminution in their number and deterioration in their physique result in the decrease and degeneration of the nation, and that a substantial improvement in the health of these classes and the prevention of the excessive mortality among them will improve the nation.

There is another fact which must also be borne in mind. The people residing in towns and cities can have their voices heard and obtain sanitary improvements, but the voiceless millions living in the rural tracts, removed far away from the headquarters of the district, and thus not easily accessible to the personal observations of the superior officers, have no such facilities.

In consideration of the vastness of their number, in consideration of the very large amount of revenue which they contribute to the Imperial and Local Governments, in consideration of the fact of their helplessness and of the tracts in which they reside not being seen often by the superior officers as is the case with the towns and cities, I earnestly urge that the Government will take up the case of improvement of village sanitation in right earnest and spend a far larger amount on the measures required for the improvement of the health of the people residing in the country side, for preventing the spread of epidemic diseases among them and for placing in their hands far greater facilities for obtaining medicines and medical aid than is done at present.

With these preliminary remarks I shall now take up in detail the several points which, in my opinion, deserve special attention.

Water-Supply.

It cannot be gainsaid that the improvement of the sources of the supply of water used for drinking purposes in the rural areas occupies the first and foremost place in the list of sanitary measures.

Modern science of hygiene has established that the use of water taken from impure and contaminated sources produces many diseases. Cholera, which carries off every year such a large number of human beings, is a disease which can be prevented, to a very large extent, if water-supply be unpolluted and free from impurities. Improvement of the sources of water-supply should therefore engage the most earnest attention of the Government and of the local authorities. The measures for the attainment of this object are :—

(*a*) Construction of new wells for drinking purposes where suitable ones do not exist;

(*b*) Adoption of measures for protection from pollution and contamination of wells used for drinking purposes;

(*c*) Periodical examination of all wells used for drinking purposes in order to find out whether their water is fit for human consumption or not;

(*d*) Periodical purification of these wells.

I shall now take up in their order the measures enumerated above.

(*a*) *The construction of new wells.*

In the discussion on this point I leave out the villages whose inhabited sites stand close to the banks of large rivers and streams and the inhabitants take water for drinking from those sources. I exclude also the villages in the Himalayan districts, because their sources of water-supply are different from those in the plains. The first step should be to have an enquiry in the villages in each District made by special officers deputed or appointed for the purpose. The object of such enquiry should be to ascertain which of the villages have got wells the water of which is not fit for human consumption. Experience shows that there may exist a large number of wells in a locality, but their water may not be fit for drinking. The case of the City of Lucknow may be cited to illustrate this proposition. As a preliminary step to the introduction of water-works in the city, a survey and inspection of the majority of wells then existing were made, in the eighties, by Major Cunningham, an officer specially deputed for the purpose. On examination he found only two or three wells in the whole city with water that could be used with safety.

The number of villages in the 48 Districts of the United Provinces is 104,584. Out of this number 10,188 villages in the Kumaun Divisions must be left out, and deducting them, the number of villages in the plains remains 94,360. It may, I think, be assumed that at least fifty per cent., *i.e.*, half of these villages, have wells whose water can be used with immunity from diseases. There remains the other half numbering 47,180. For the present, the construction of at least one good masonry well in each village may be taken in hand; their number would come to 47,180. The amount of cost is the most important factor in the consideration of this point. I cannot say from personal experience what is the cost of sinking of a masonry well in the Western Districts; but in the Eastern Districts the cost of a masonry well of moderate dimensions, generally ranges from Rs. 250 to 500. Let us assume that the average cost of a masonry well in the Western Districts is nearly the same as in the Eastern, the average cost of a well would come to Rs. 350. On this calculation, 47,180 new masonry wells would require a total outlay of Rs. 1,65,13,000. It must be owned that this is a very considerable amount and such a large expenditure cannot be undertaken in one year or even in five. I would therefore suggest that the scheme may be completed within a period of ten years. This would require an annual cost of about 16½ lakhs only.

The most vital question which arises naturally is, from what source is this comparatively large annual sum to come. I beg to suggest that well-to-do landholders and Talukdars and estates under Court of Wards should be asked to provide masonry wells for drinking purposes in the villages owned by them, at their own cost. In the villages owned by a body of proprietors having very limited resources, the cost of sinking of new masonry wells should be borne in the following proportion:—

(*a*) one-quarter from the District fund;

(*b*) one-quarter from the proprietors and persons owning or occupying houses in the village; and

(*c*) the remaining half from annual grants to be specially made for the purpose by the Central Government.

I have already suggested that the scheme of providing new wells in the rural areas should be completed in ten years. This means an annual outlay of rupees 16 lakhs or thereabout. According to the distribution of cost suggested in the preceding paragraph, 4 lakhs would fall to the share of the District Board funds, and a similar amount of expenditure will have to be borne by the proprietors and residents of the village and the remaining 8 lakhs will have to be given yearly by the Imperial Government. The annual sums which each of the District Boards of the 45 Districts (excluding the Himalayan Districts) will have to contribute would come to about Rs. 9,000 a year, the aggregate sum which each individual District Board will have to spend during the decennium would come to Rs. 90,000.

The annual grant of 8 lakhs from the Imperial Exchequer for a period of ten years is not a large amount. It is not in the least disproportionate to the gravity of the situation. This sum is required for improving the water-supply for no less than the 42,371,430 souls, residing in rural areas.

Pure water being one of the most absolute necessaries of life and the general health and prevention of epidemics depending to such a large extent on the purity of this element, it is hoped that the Imperial Government will be pleased to make this annual grant.

The above scheme as to the proportion in which the cost of the construction of new wells is to be borne by different bodies differs from that provided in the United Provinces Village Sanitation Act of 1892 as amended by Act V of 1912.

The Act provides that when a well for drinking purposes is constructed under the orders of the Collector, its cost is to be borne in the following proportion :—

(*a*) One-quarter from the District fund,

(*b*) One-quarter from the proprietors, and

(*c*) One-half from the persons owning or occupying houses situated in the village.

It will be seen that according to the provisions of this enactment only one-quarter cost is to be borne by the public funds, the burden of the remaining three-quarters falls on the proprietors and residents of the village. For the reasons which I have stated above, only a quarter of the cost should fall on the proprietors and inhabitants of the village and a moiety of the cost should come out of the Imperial funds.

(*b*) *Measures necessary for the protection of wells from pollution and contamination.*

In order to protect wells used for drinking purposes from pollution and contamination the following measures should be taken :—

(1) Such wells should not be allowed to be used for irrigation. The water of wells becomes muddy, when taken out continuously for a number of hours for irrigating the fields.

(2) In many cases the wells are situated in localities where the drains of the surrounding houses pass through them; the dirty water of those drains percolates through the ground and contaminates the water of the wells also. The existing drains on such spots should be diverted and no new drains should be allowed to pass through that ground.

(3) There are no platforms round many wells, and the platforms of others are very low. The result is that the storm water with all dirt and refuse falls into the wells and contaminates the water in them. New platforms 2 or 2½ ft. high should be built round them, and low platforms should be raised.

(4) In many places trees exist on the ground surrounding the wells and their dead leaves fall into the wells and make the water unfit for drinking. Such trees should be removed. Corrugated iron covers, which do not cost more than Rs. 30 each, should be placed on each well.

(*c*) *Periodical examination of wells.*

There should be a periodical examination of the water of wells used for drinking purposes. These examinations should be made quarterly and when cholera appears in the village itself or in its neighbourhood, the Chowkidar and the Putwari should report the matter at once and an examination of the water of the well should be made forthwith.

(*d*) *Purification of wells.*

When cholera breaks out in the village or in its neighbourhood the water of the wells should be purified by permanganate of potash. Dirt and dead leaves should also be taken out periodically.

Filling up of hollows, pits and stagnant pools.

Hollows, pits and stagnant pools within and in the vicinity of village sites are usually very dirty, and when filled with rain water serve as breeding places for mosquitoes. In order to prevent the spread of malaria it is necessary that they should be filled up. They are caused by the villagers taking earth for building purposes. New excavations are also made for the same purpose. Making new excavations should be stopped altogether not only within the inhabited site itself but also on the grounds immediately surrounding the site.

Cleaning the village site and removing jungle, etc., from it.

Bushes and plants of wild growth are found in the inhabited portions of villages and in their immediate neighbourhood. They contribute to the unhealthiness of the villages. They should be removed after the close of the rainy season.

On the vacant spaces in the front as well as on the back of their houses, the village people stack rubbish and sweepings of their houses and cattle-sheds for using the same as manure. Their unwholesomeness is accentuated when rain falls on them. A total prohibition of them would deprive the cultivators of materials used for manuring their fields. I would suggest that the practice of stacking manure and household refuse within the inhabited site should be stopped and open spaces removed at some distance, should be set apart for this purpose.

Pigsties which are a great nuisance in some villages should be located altogether outside the inhabited site and at some distance from it.

Travelling Dispensaries.

The paucity of institutions to afford adequate medical relief to the very large number of rural population is self-evident. The introduction of the system of travelling dispensaries has worked very well, and all that is required is to increase their number so that it may become possible to give medical relief to the inhabitants of villages to whom the existing dispensaries and hospitals are not accessible at all, or accessible with difficulty and at great expense.

Legislation on the subject of Rural Sanitation.

Legislation, at present in force on the subject of rural sanitation in the United Provinces, is contained in the Local Council Act, II of 1892, amended by Act V of 1912.

In the Manual of Government Orders, Department XVI, pages 156-160, instructions and rules framed under section 20 of the Sanitation Act are also given.

In the District Board Manual also there are given G. Os. Nos. 268/XVI-401 B.-8, dated 14th September 1896 and 338/XVI-401 B.-45, dated 13th May 1897, respectively, which contain general directions relating to village sanitation. So far as the framing of rules and laying down of necessary instructions go, nothing is left to be desired. But the question is how far those rules have been enforced and the instructions carried out. The two things which have stood in the way of the progress of village sanitation are (*a*) absence of necessary staff, and (*b*) want of funds.

Appointment of the staff to carry out the measures of sanitary improvement and reform.

I now take up the question of the staff required for the carrying out and supervision of measures for the improvement of rural sanitation and the agency required to help such staff.

Para. 2102 of the Manual of Government Orders, Department XVI, p. 156, lays down the duties of civil surgeons with regard to village sanitation, but I am afraid that these officers in the districts with head-quarters in large towns have no time to look after rural sanitation.

In the Provincial Sanitary Conference held at Naini Tal in 1908 there was a long discussion on the question of the appointment of sanitary staff, but the points then discussed and recommended by the Conference related to the appointment of such staff for urban sanitation. This is evident from the report of the Sub-Committee of the Conference on Sanitary Staff and Supervision. So far as rural Sanitation was concerned no detailed scheme was either proposed, discussed or recommended. That Sub-Committee contented itself with recording its opinion to the following effect:—

"That it was desirable that an assistant surgeon should be appointed as assistant district health officer in each district. The attention of the Government should be drawn to rule 2-XVI Sanitation Department, which it is hoped will be carried out as soon as possible. The main duties of this officer will be to look after rural sanitation, but he will also be Health Officer to the small municipalities at head-quarters in many districts."

It is submitted that the above opinion does not go beyond the expression of a pious hope. The appointment of qualified and efficient staff for the supervision and carrying out of measures relating to rural Sanitation is the first necessary step.

The work of sanitation should be performed both by official and non-official agency.

(*a*) The staff should consist of Assistant Health Officers for every district assisted in their work by at least two sanitary inspectors and a number of jamadars and peons under these inspectors. This staff should be under the control of the civil surgeon of the District who is the head of the Health Department and *ex-officio* Health Officer of the District to which he is attached, under the rules given in G. O. No. 53A., dated 8th October 1887, para. 2102, p. 156, Manual of Government Orders.

(*b*) The non-official agency should consist of a Panchayat constituted out of the respectable and influential residents of the village. It should be entrusted with the duties of apportioning the levy of any monetary contributions which may be required for the purpose of village sanitation. It should supervise the carrying out of such sanitation works as the filling up of hollows, pits and stagnant pools, and keeping the inhabited sites clean.

The question of appointment of village Panchayats was discussed before the Naini Tal Sanitary Conference. Six members voted in favour of the proposal of

the creation of village Panchayats for every village or group of villages for the management of village affairs so far as they relate to village sanitation. But in the opinion of others who formed the majority their creation was premature. But I am glad that the Local Government has commenced the creation of village Panchayats in some Districts.

The Royal Commission on Decentralization in paras. 701 *et seq* of their report recommended the creation of such Panchayats.

In paragraph 711 the Commission say as follows :—

" The next sphere we would suggest is a delegation to Panchayats of expenditure for the construction and repair of local minor works such as wells and drinking water tanks, the cleansing of the village, and the upkeep of village roads, and of buildings such as rest-houses for travellers. It is generally admitted by persons conversant with Indian conditions that the attempt to force rural sanitation from above has failed, and we think it desirable to encourage Panchayats to keep their villages clean in their own way. A fair chance should also be given to them to show that they can do justice to other communal work, of the character above described."

When any religious ceremony is to be performed or any festival is to be celebrated collectively by the villagers, the elders assemble together and apportion the share of cost which each family has to bear and they submit ungrudgingly to pay the contributions so apportioned.

It is submitted that the time has come when village Panchayats for the purposes above indicated may be constituted for each village or group of villages not in a few districts only but in all the districts in the province.

Expenses.

I shall now make a few suggestions on the last—though the most important—point in this subject, *viz.*, from what source or sources the expenses required for the introduction of and carrying out the measures for the improvement of village sanitation are to come. These expenses will be of two kinds, non-recurring and recurring. In the first category may be included the cost of constructing new wells which is the heaviest item. I have already suggested from what sources it ought to come. The next item is the cost of filling up pits and hollows. This will require a comparatively smaller sum which ought to be met from contributions to be levied on the residents of the villages and proprietors.

We now come to the recurring charges. The heaviest item in this class would be the salaries, etc., of thes anitary staff to be retained. A rough detail is as follows :—

(1) One assistant Health Officer for each district at Rs. 250 per mensem. The annual salaries of the 48 of such officers would come to Rs. 1,44,000.

(2) The cost of their offices, say at about Rs. 500 per mensem each. This will amount to Rs. 28,800 a year.

(3) Two Sanitary Inspectors for each District, at Rs. 50 per mensem each. 96 Sanitary Inspectors would cost Rs. 57,600 annually.

(4) Ten Jemadars and peons for each district, *i.e.*, 480 in all, at Rs. 10 each, would cost annually Rs. 57,600.

The total of annual salaries, etc., comes to Rs. 2,88,000; adding to this Rs. 1,12,000 a year for other expenses, the whole amount comes to Rs. 4,00,000 a year.

This amount, together with the 4 lakhs required for the construction of wells, is the annual sum which the District funds will have to contribute for rural Sanitation. Of course these are very rough details which if worked out more carefully and minutely may vary considerably.

But after taking all these factors into consideration, can it be said that this amount is too much when it is required for the preservation and improvement of health and for saving the lives of more than 42 millions of souls residing in rural areas?

During the present financial year the proceeds of local rates and cesses have been relieved of rural police charges which amounted to Rs. 32 lakhs a year. Out of the sum so set free, Rs. 8,00,000 as indicated above may very appropriately be spent annually on the improvement of sanitation of the very people who pay that amount.

VILLAGE SANITATION.

BY

THE HON'BLE MR. K. R. GODBOLE, M.C.E.,

Non-official Member, Sanitary Board, Bombay.

I PROPOSE to refer in this note to some points regarding the question of sanitation in an Indian village. The note refers to villages in which there are no municipalities and applies specially to Western India. It is presumed, however, that the remarks made and measures advocated will apply to villages in other parts of India also.

2. In my opinion the points that require immediate attention in an Indian village, so far as its sanitary condition is concerned, are wholesome drinking water-supply, clean surroundings to ensure uncontaminated atmosphere, and surface drainage. There are such questions besides, as the stabling of cattle in residential buildings, stacking manure close to residences, defective or no ventilation in sleeping rooms, etc., but the consideration of these must stand over until sanitary education makes some progress and creates a sanitary conscience in our rural population.

3. As regards water-supply, sustained efforts are being made to give to each village one or more drinking water wells situated in clean localities and so constructed as not to get easily polluted, the required funds being provided from local funds supplemented by grants from Imperial and Provincial assignments.

4. The second requisite is clean surroundings. One of the great enemies that come in the way of this requisite, is wild prickly pear growth and the growth of other noxious vegetation. This growth, if allowed to go on unchecked, spreads very fast. In some villages, the evil has spread to such an extent that blocks of houses on the outskirts of the village site and some of the adjoining fields have got smothered up in tall prickly pear occupying large areas.

5. The growth of prickly pear and of other noxious vegetation is harmful in several ways :—

(*a*) It stops perflation by currents of air.
(*b*) It harbours dirt and filth.
(*c*) It harbours jackals, wild pigs, snakes, wild rats and other vermin which cause great annoyance to villagers.
(*d*) It affords screened places and enclosures where villagers answer calls of nature.

6. The last named evil (*d*) is a very serious one. Any one whose business and duty make it necessary for him to go round an Indian village in the early morning must have noticed how filthy the surroundings are. One has to go about with great circumspection and with a handkerchief against one's nose. The smells are vile and overpowering. Almost at every fourth or fifth step, one is in danger of treading upon human ordure.

7. The above state of things requires to be remedied as far as practicable. I propose, therefore, that this prickly pear and other wild and noxious growth and vegetation should be thoroughly eradicated from all village sites (gaothans) and within 40 yards from the same. The space being cleared and open, it is then less likely to be used for latrine purposes. The prickly pear and other vegetation should be rooted out and burnt or buried deep in the soil, so that it will not sprout again.

8. The third requisite that I have alluded to, is surface drainage. I propose that all depressions in village sites (gaothans) and within 20 yards of the same, should be filled up, or so drained as not to allow any pools of water to stagnate. Such pools become the dumping grounds of filth and dirt from adjoining houses, and the stench they give rise to is awful. The pools become breeding-grounds of mosquitoes and cause malaria and other diseases in the village. Some of the pools become sullage depôts also. The surface drainage recommended should therefore be carried out thoroughly and efficiently.

9. The removal of prickly pear and noxious vegetation and the surface drainage that I have recommended in paragraphs 7 and 8 above are simple works, but they will be very expensive on account of the large number of villages that have to be

dealt with, all over the country. The average expenditure for each village need not, however, exceed Rs. 100 or thereabouts. The question is how to provide for the requisite funds, and through what agency should the works recommended be carried out.

10. I recommend that the agency should be special sanitary overseers and sanitary inspectors working in co-operation with the sanitary committees and sanitary boards established under Acts like the Bombay Village Sanitation Act, I of 1889. Where such committees or boards are not in existence, their place should be taken by the taluka local boards concerned. The whole scheme should be under the general control and supervision of the Sanitary Commissioner of the local government and his deputies.

11. The funds for carrying out the works should be drawn from the local funds and funds raised under Acts like the Bombay Village Sanitation Act, I of 1889, supplemented largely by *liberal* grants from the provisions in Provincial and Imperial budgets on account of grant-in-aid to local bodies for sanitary projects.

12. The execution of the village sanitation improvement scheme that I recommend must necessarily be spread over a long period, and its details carefully considered by the sanitary advisers of Government and the district officers concerned. It will be desirable to associate selected native gentlemen also, in formulating the scheme. I would recommend that each local government should take up a group of 10 or 15 villages and carry out the scheme in this group, in the first instance. It can be extended gradually afterwards to other portions of the province.

13. The following questions will have to be dealt with after the eradication of prickly pear and noxious vegetation and the carrying out of the surface drainage in a village as the special sanitary overseers and sanitary inspectors referred to in paragraph 10 above, will not then be available for executive work :—

1st. The upkeep of the improved sanitary condition of the village ; and
2nd. The provision of latrine conveniences.

Where there are sanitary committees and sanitary boards established under Acts like the Bombay Village Sanitation Act, I of 1889, these questions will be dealt with by those bodies. I hope that the number of these bodies will steadily increase, and that every village or group of villages will have its own sanitary committee or board in the near future. The constitution of the sanitary committees and sanitary boards should be amended to make these institutions more effective. They are far from being efficient at present.

14. In the case of villages without any sanitary committee or sanitary board, the taluka local board will have to step in, and look after the upkeep of the sanitary condition of such villages by entertaining special establishments if necessary.

15. Public latrines should be provided wherever practicable. This ought to be comparatively cheap in the case of irrigation villages growing sugarcane and other crops requiring heavy manure. There is keen demand for manure in such villages, and it will probably financially pay to employ regular bhangis here and turn night-soil into poudrette for manurial purposes. The Sanitary Board in the Bombay Presidency are considering such a proposal, at present. It is contemplated to select two substantial irrigation villages under the Mutha and Nira canals in that Presidency and to provide latrines for them, the night-soil being trenched and converted into poudrette for the purposes of manure which it is expected will find a ready sale locally. It is proposed to entertain a special staff of bhangis, all the initial expenditure being borne by Government. It is hoped that when the poudrette is manufactured, the scheme will become self-supporting if not profitable, after the first 12 or 15 months.

16. There will be another class of villages where public latrines and regular bhangis will be impracticable, but where it will be feasible to have separate enclosures for men and women to which the village population can go for easement purposes. These enclosures can be worked on the trench system, where sweepers for excavating and regulating the trenches can be obtained. If no sweepers are obtainable, the cleaning must be left to the Indian sun, and to those inexpensive and ever willing scavengers, namely, the village pigs. The latrine enclosures must, of course, be so located that the surface drainage from them will not pollute existing sources of water-supply for men and cattle.

17. In the case of smaller villages and hamlets, the population will have to go to places beyond, say 20 yards from the village site, for easement purposes. The number to be dealt with in these cases being small, the nuisance will not be very serious.

18. As regards surface drainage, the annual expenditure and labour of maintenance and upkeep will be very limited. All that will be required will be a little clearance work here and there, from time to time.

19. I think the annual cost of upkeep and maintenance of the sanitary condition of a village when once put in order should be within Rs. 5 in the case of a smaller village, and Rs. 10 in the case of a larger village. These amounts are for keeping up efficient surface drainage and for keeping out prickly pear, etc., from gaothans and their surroundings. Where sweepers are maintained for road cleaning and latrine

purposes, the charges will, of course, be higher. The question is where are the requisite upkeep funds to come from ?

20. I offer the following solution of this problem. I think that a fixed proportion of the local funds contributed by each village, should be earmarked for expenditure in the village itself. This amount supplemented by voluntary subscription and grants from Imperial and Provincial funds should be utilised in the upkeep of the sanitary condition of the village, and where funds are available in sweeping roads and open places, attending to latrine conveniences, and so on. The funds should be placed in the hands of sanitary committees and boards or taluka local boards, for expenditure, or they may be placed in the hands of village panchayats if such can be brought into existence. The upkeep of sanitary conditions of villages should be under the control of the Sanitary department. The existing Sanitary and Vaccination Inspectors and Vaccinators of the Sanitary department will be of great use in the requisite supervision and guidance. The status and education of the Vaccinators must be improved before they can be utilised to assist in the work of village sanitation supervision.

21. The proportion of local funds to be earmarked is difficult to determine. I would suggest one-sixth as the proportion. One-third is to be devoted to educational purposes. Of the remaining $\frac{2}{3}$ I would retain $\frac{1}{4}$ for expenditure in the village itself, the remaining $\frac{3}{4}$ being available for expenditure on communications, medical relief, general sanitation, etc. To take a concrete example, suppose the local funds revenue of a village is Rs. 90 per year, Rs. 30 will go to education. Of the remaining Rs. 60, I would keep Rs. 15 for expenditure in the village itself, the balance of Rs. 45 being available for communications, medical relief, vaccination, general sanitation, etc., in the district concerned. Rs. 15 with voluntary contributions and a contribution from provincial funds, will be spent on the upkeep of the sanitary condition and conveniences of the village.

22. The above proportion of one-sixth will secure small amounts and one would think that very little could be done with them. But when villagers feel and see that some of the money contributed by them as local cess is being spent in their own village and near their homes, and in some cases by themselves, they will naturally commence taking more interest in their own sanitary affairs and be more likely to enhance the funds available by voluntary contributions. Again it must be remembered that village servants and Mhars and Mangs will do a great deal of work in their own village, if only a small but regular money payment be made to them. In an outlying village, it will be easy for instance to get a woman sweeper to clean the village roads on Rs. 2 or 3 per month. So even small sums will secure a good deal of work, especially in villages that are at distances from cities and Taluka towns.

23. When the local fund shares available in villages are very small, two or more villages can combine for sanitary purposes and get what is required to be done by joint action, and by their funds put together to form a common fund.

24. The suggestions made in this note are tentative, and are put forward to see if any practicable scheme can be worked out for improving the sanitary condition of Indian villages, without additional taxation. It has to be noted that speaking from a sanitary point of view, the condition of an Indian village is deplorable. Very little has been done hitherto to improve it, except as regards the provision of drinking water-supply.

25. The above scheme is subject to modification in the light of any suggestions and remarks. The Sanitary and Revenue Officers of Government are in the best position to give sound and practical advice on the subject.

MEDICAL INSPECTION OF SCHOOLS AND SCHOOL HYGIENE.

BY

RAO SAHEB GANESH NAGESH SAHASRABUDHE,

Vice-Chairman, Ellichpur Camp Municipal Committee.

A WRITER has said :—" Health is the parent of happiness ; the two bring into being a cheerful worker; the cheerful worker acquires wealth; wealth provides the sinews of education; and education conduces to national prosperity."

Importance of health and sanitation.

Immediately connected with " health " is the science of " sanitation." The importance of health and sanitation has been recognised and acknowledged on all hands. Attention of both Government and public has been directed to this all important subject. Rural and Urban sanitation have become the standing subjects of discussion in Conferences and Congresses all over the country. Constant endeavours of Government to build up a body of scientific workers for investigation, provision of laboratories to carry on experiments, appointments of specialists and a band of workers in the Bacteriological Department—opening up of Research Institutes for ascertaining the causes of " Tuberculosis " and other dangerous diseases, sessions of the Medical Congress in London—all these point to the appreciation of the high value and importance of health and sanitation.

In short in every society—Hindu, Mahomedan, Christian—health and sanitation have been looked upon from time immemorial as the most essential factors conducing to the health and comforts of man in this world. Our ancient Rishis have taken the same view ; they have even embodied the principles of health and sanitation in sacred books as dictates of religion.

Hence it is clear not only that the first thing to be striven for is health, but that a special care and thought should be bestowed and directed to the observance of rules of health and hygiene in regard to the young.

A visit to a village school.

A visit to a village or middle class school in the province gives one an idea as to the deplorable condition of the health of the student population and general school hygiene in the province. Lean faces, sickly bodies, and the generally dirty clothes worn by the boys, testify to the lack of care and attention paid by parents, guardians or teachers to the welfare and health of the children. School buildings and their surroundings, especially in villages, show a disregard to the principles of hygiene and sanitation. There can be no two opinions as to the desirability of making attempts to combine physical with mental education, with a view " to make men with strong brains, as well as muscles." Movements have been set on foot, both in India and foreign countries, to improve the physique of the boys and make them fit citizens. But the physical training cannot be properly undertaken, without medical examination of boys, when they attend the school. The object of this paper is, therefore, to signalise the importance of the introduction of the systematic and thorough medical inspection of boys in C. P. and Berar schools, and generally in all schools in the country.

Dr. Louis Parkes, M.D., of London, in his work on " Hygiene and Public Health " thus describes the nervous system of the child :—

The nervous system of the child.

" The development of the nervous system of the child is one of great importance from the educational standpoint. In childhood, especially from 3 to 10 years of age, the nervous system is unstable, rapidly developing and easily tired; since body and mind act and re-act upon each other, the body suffers if excessive demands are made upon the brain and the brain suffers if excessive demands are made upon the body. The coarse large movements of early childhood slowly become finer, with gradual development of the complex co-ordination necessary for fine movements. Thus up to 5 years of age a child should be educated through senses

nd activities, then the memory should be developed and good habits and train-ng should be cultivated ; after 10 years of age the child's reasoning powers and magination develop. Probably the chief period of character-formation is from to 8 years."

Effects from "cramming."

It cannot be denied that school children often suffer from some disease or other during their early age. Neither parents, guardians nor teachers care to take notice of this matter. Naturally as the boys advance in age, the disease develops. Besides, t may be noted that the masses of the rising generation are being educated at too igh a pressure. They are in fact having too many subjects crammed into them, njuring, if not wearing out, their power of mental digestion. Considering the ervous system of children as described above, it is not surprising that owing o strain on the brain many children do suffer in the end. Viewed in this ght, Mr. Montagu's (Under-Secretary of State for India) reference, in his last elebrated Budget speech, to "Text-book cramming," was indeed happy and ncouraging.

The International Congress of London on medical inspection of schools.

The subject of school hygiene and medical inspection of school children was put on the Agenda paper of the second International Congress held in London in 1907. The subject was fully discussed by eminent people and experts on the subject, and its importance signalised. It was said "among the most important results of the increase of scientific knowledge, are the efforts to provide public supervision over the hygiene and sanitary conditions of communities. In those efforts, the important need of such service in connection with public schools, and of making the schools media for diffusing knowledge upon these subjects, has been distinctly recognised. The various ways in which schools may conduce to the physical well-being of the pupils, and to the progress made in the countries represented in the Congress in establishing some form of hygiene or medical inspection of schools, were very clearly brought out in the general sessions of the Congress." Lord Crewe in his presidential address said "that he hoped that the meetings might leave some permanent marks on the subject and that the deliberations of the Congress would do much to advance the knowledge of school hygiene and remove what all must regard as having been a serious blot on the civilization of the world."

Medical inspection of schools in England, Education Act, 1907.

As a result of the above deliberations, the Boards of Education in England and America have practically introduced the system of medical inspection of school children. In England, the Education Act passed in 1907 requires the medical examination of all elementary school children at the period of commencing school attendance and on such other occasions as the Board of Education may direct.

Medical inspection of schools in America.

In America the conviction is growing that the school should minister to the physical as well as the mental side of the child, and that physical soundness in children makes for efficiency in study. Efforts on behalf of the health of school children have been marked by the introduction of medical inspection, the improvement of sanitation and school hygiene, and the provision of special rooms and schools for the more pronounced types of the physically unfortunate.

In 1910 according to the return published by the Russel Sage Foundation Department of child hygiene, there were 400 cities with the system of medical inspection. From these figures it can be seen at a glance that the phase of public school work has developed with great rapidity in America.

Preliminary difficulties.

The system of medical inspection can be gradually and advantageously introduced in the schools of this country. I think that the new system will meet with some opposition from the people. The popular attitude will be hostile for some time, as usually is the case with every new measure all over the world. The experiment in foreign civilized countries is even the same. I think the opposition will be overcome gradually and wiser counsels prevail, when the people see the good sense and advantages of the inspection.

Preliminary difficulties experienced in America are described below and are interesting :—

"The present system of health inspection in the public school was inaugurated in April 1906. The experiment was not made without opposition. The public had to be brought to a realization of what it all meant. There are those who thought bodily harm was to be done to children. Others were moved by a false sense of pride and were insulted at the insinuation that they were not careful of the welfare of their children. A strong feeling of antagonism was manifested by some. There were those who did not wish their sons and daughters to be examined except by the "family doctors." In fact, in one case a child was excluded from school, because his parents persisted in forbidding

the Inspector to examine him. As soon as the child was taken from school, the law regarding "truants" was brought into force and acted upon, and after a while, the parents were made to see the good sense of inspection."

Suggestions as to how medical inspection can be made possible and the agency to be employed.

In my opinion parents and guardians will be glad to know the disease from which their children suffer; those who are in a position to spend money will entrust their children to the treatment of a doctor, and the poor will be treated in the nearest dispensary.

In the beginning, the scope of the inspection may be confined to those schools only which are in the towns where there is a dispensary maintained by Government or District or Municipal Boards. The Assistant Civil Surgeon or Sub-Assistant may be given a suitable allowance for the additional work of inspection he may have to do. The Medical Officers should examine (I) the general conditions; such as (*a*) weight, (*b*) height, (*c*) nutrition, (*d*) cleanliness, etc. (II) Special conditions, such as (*a*) nose, (*b*) throat, (*c*) eyes (vision), (*d*) ears (hearing), (*e*) mental condition; and (III) diseases and deformities such as heart and circulation, lungs, nervous system and any other defects. They should then submit their reports to the Head-master and to the Inspector of Schools of the Division. The Head-master should inform the parent or guardian of the respective children of the Medical Report, who will then see that their children are treated by a Medical Officer, the poor boys being sent to the Dispensary for treatment. Medical Officers should attend to children regularly and give a final discharge certificate of cure. If anybody is found suffering from contagious disease, a report should at once be made to the Head-master, who should take steps and see that the contagion is not spread.

Question of money.

For the present the inspection should be made through the agency of the existing Provincial Medical Department, an Educational Department and District and Municipal Boards should exercise supervision over their work. They should supply the necessary funds which should be supplemented by Government contribution as far as funds permit. The system can thus be made possible in the country.

If the system proves a success, the scope of the inspection should be enlarged and extended to many other schools in the country, and a Board of Health established under the supervision of the Educational Department of the Province, with an addition of a number of Medical Officers, sufficient to cope with the increased work.

The education of teachers and school children in hygiene is just as necessary along with the medical inspection of schools.

The education of teachers and school children.

School hygiene should be taught as a compulsory subject in training schools. The elementary principles of the Science should be well studied by the teachers before they are appointed as school-masters. Similarly, a small primer, dealing with the elementary principles of sanitation and health should be introduced in the course of the primary schools, and the following good suggestions made by Major Stokes, M.B., I.M.S., the Sanitary Commissioner, C. P. and Berar, in his lucid and interesting annual Sanitary Report for 1912, may be followed with advantage :—

"A short note upon the cause, prevention, and treatment of epidemic diseases has been drawn up and the Director of Public Instruction has promised to issue it in the vernacular to all school masters to secure their co-operation in all efforts so directed. A small book on "Village Sanitation" has moreover been written to suit the condition of the Province, and it is hoped that its issue to school-masters, policemen and vaccinators will lead to the dissemination of elementary knowledge among them and so amongst those with whom they come in contact."

School Hygiene.

Connected with the question of medical inspection of schools, is the question of school hygiene. "The Principles of School Hygiene" are excellently illustrated in Chapter X of "Hygiene and Public Health" by Dr. Parkes, M.D.; certain directions are to be followed, in (1) selecting a site for a school, (2) in planning a school building and school-rooms, (3) in the matter of lights and ventilation, (4) in the construction of windows and arrangements of seats, desks and black-boards and many other matters of a like nature.

Phases of school hygiene that have been of the most interest in the past few years have been the movement in America to abolish the common drinking cup—the provision of better equipments for the elimination of dust and dirt, and the installation of more hygienic school furniture. Provision for the elimination of dust and dirt are to be found in the form of moist cloths and dust-absorbing compounds for sweeping, etc. By these means the dust and dirt are entirely removed instead of merely stirred up by the old-fashioned broom and feather ouster.

The ideal of School Hygiene as promulgated in England and America and described above is a grand one, though it is not possible to follow that ideal in

India for the present. But the Government may be pleased to build some model school-houses in Presidency Towns as an experimental measure strictly on the principles of School Hygiene. The American and English ideal will be reached gradually as the education advances and the circumstances of India improve in course of time.

Writer's proposals.

The Annual Sanitary Report of C. P. and Berar for 1912 shows that there is Medical Inspection of Schools in force at present in the province. The Educational Manual provides for it, and a modest beginning has been made in the Central Provinces. On the Bombay side the Honourable Mr. Lalubhai Samaldas moved a resolution on this subject in the last meeting of the Bombay Legislative Council, and a promise was made by Government that a similar scheme was under their consideration and something practical would be done in the matter. In the Punjab a scheme for the medical inspection of Government schools is under consideration and a certain amount has been provided in the Budget. The Government of United Provinces appointed a Committee to report on "Educational Hygiene," composed of Lieut.-Col. Young, I.M.S., Major Graham, Capt. Dunn, Mr. Banister, and Rai Gokul Prasad. The Committee made many recommendations, the most important being the periodical inspection of the sanitary condition of all schools, and periodical inspection of all scholars by qualified doctors. The system does not seem to be in other in other Provinces. Looking to the laudable efforts of Government in other directions and to the research of various theories of numerous diseases affecting the health of the people, the time has come, I think, in order to keep pace with the progress of the world, to introduce a more systematic and thorough medical inspection of schools.

If my proposition is accepted the detailed scheme is a matter for future consideration.

THE UNHYGIENIC AND THE INSANITARY CONDITION OF BOYS' AND GIRLS' SCHOOLS IN CITIES.

BY

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THERE are some diseases which contribute largely to the roll of human mortality, and which, when appearing in an epidemic form, can most appropriately be compared to the wrath of God. In virulence and violence no other disease equals them. As to their ætiology, there are differences of opinion even among the scientists. Round them goes on a war of theories redoubled and strengthened by new researches. Each theory leaves an impression of conviction on the mind, but the deeper one goes into them, the larger is the number of doubts that arise which remain unsatisfied. While doing all that it can to put a stop to such diseases and to completely eradicate them, the Government with its plentiful resources has to halt and take breath, as yearly expenditure to suppress them reaches to a fabulous figure. Such diseases are Plague, Malaria and Cholera.

But there are other unhygienic matters, which, unlike the above diseases, do not carry away human beings rapidly and fast, which do not get ablaze at once and spread like a wild fire, but in action they are sure and undermine the constitution like a slow poison and sap the vitality by degrees. In ultimate effect they are not less dangerous, the only difference being, that the poisonous effect comes into prominence after the lapse of a certain numbers of years. In the first case a very large amount of money is required to check the evil, while in the latter a little more attention and a modest sum can save the situation, avoid the peril, stop the progress and convert an appalling figure into a cheerful one. To the last class belongs the insanitary and unhygienic condition of the schools, which demands as much attention of the Government and the people as the other more fatal diseases.

It cannot be denied that the tender age, like wax, is susceptible to getting impressions, rapidly and easily, and that the impressions received at an early age last long and develop with the advance of years. The diseases so caught become stubborn and ineradicable and defy the skill of even the best doctors. It is absolutely necessary from social and economic points of view that every possible care should be taken to keep our children free from the hold of such diseases. It is rightly said that the boys of to-day are the fathers of to-morrow, and the girls the mothers of the future generation. If in mental and corporal strength they are found wanting or possessed of deteriorated health, the whole structure of the community and its progress and advancement is vitally affected.

The children are our national assets. The normal condition of the nation is reflected through their health and strength ; they really serve as a true mirror as to its vitality and growth. Education, no doubt, is essential to broaden the mind, to sharpen the intellect, to generate intelligence, to prepare human beings to understand their duties to their king and to their fellow-creatures of God, and generally to shape true manhood. It is a matter of great pleasure that India under a beneficent rule is making progress in education by strides, and the Government of India, as far as its financial condition permits, has done its utmost to stimulate the desire to acquire knowledge ; but the strain of education can only be properly borne with a good physique, and education at the expense of health and sanitation, is not only undesirable and injurious, but like a poisonous fruit, though sweet and delicious, ought to be forbidden.

Thus it is quite clear that there should be as much eagerness for sanitation in schools as there is for education, nay, even more than that. There is yet another reason why perfect hygiene in schools should be insisted upon. The school attracts children from different quarters of a city. The sons of the rich and the poor read alike in one school. They mix with each other, and possibly interchange many ailments which are carried back to different quarters, to become a source of further

danger. The school itself absorbs many kinds of poisonous germs brought from different parts of the city, and transmits many maladies to differen quarters through the medium of its students. Thus purity is not only absolutely necessary but indispensable.

For the purposes of this paper I shall confine myself to the boys' and girls' schools in towns, as rural schools do not suffer comparatively from so many shortcomings as the schools in cities. There the sun, open space, pure air, and simple habits are powerful factors to counteract the evils produced by the insanitary conditions of school life.

Before describing the present condition of school buildings, their appliances, their architectural and other defects, I would point out that the laws of sanitation are not the monopoly of any particular class of people. They are the natural laws, and the sinner must pay the penalty.

Two great truths are gradually dawning upon humanity :—

(1) The necessity of beginning all reforms with the child.

(2) The avoidance of unnecessary delay in diagnosing and curing the evil.

I readily admit that the unhealthy condition of the students is not due exclusively to the insanitary conditions of the schools. There are other causes, such as malnutrition, early marriage, the insanitary condition of the houses in which they live, filthy environment, and last of all but not the least, general poverty, but we cannot free the schools and the method of teaching from blame as they are in no less degree culpable, and largely contribute to or facilitate the development of the evil.

First of all I take up the girls' schools. It is a matter of congratulation and a hopeful sign, that the people have come to realise that the education of girls is as indispensable as that of boys, that the needs of the country demand that girls be educated and that the country cannot grow in prosperity and happiness without such education. The education of boys and girls should go hand in hand, and modern history fully demonstrates that only those countries have advanced in civilization and come to the front rank, in which women are as much educated as men. It fills the mind with inexpressible delight to see every morning girls, with satchels under their arms going to school, perhaps with more activity and eagerness than can be found in the faces of boys. In Amritsar there are not less than 5,000 girls in these days reading in the girls' schools, but the heart saddens and is overpowered with grief, when we ponder over the state of the so-called schools to which they go. Excepting one institution, which is managed by European missionary ladies, the condition of the schools is such that the less said the better. Their's are not school buildings constructed on any hygienic principles, but only consist of certain stories of private houses in streets, rented to accommodate the girls. Literally speaking, they are dark and filthy *kothris*, ill-ventilated, without proper means for letting in sufficient air, and sometimes merely lower flats, quite damp and unhealthy. The girls have to pass the whole day in such apartments, with no arrangements for even a decent urinal or latrine, nor for punkhas in summer, or fire stoves in winter. There are no benches and the scholars are made to sit on the floor. The rent of such houses ranges between 2 to 5 rupees a month and overcrowding is frequent. Even the Central Municipal school does not set a good example to others. It cannot boast of any ground for the recreation of the girls : they have no space to walk about, far less to play : they can't breathe fresh air even for a moment. Education in such hovels for many years before the marriageable age may, no doubt, enlighten the minds of the girls, but it leaves them with broken health, with no freshness of colour or cheerfulness, emaciated and in a shattered condition. How can such girls meet the hardships of life ? Can such a state of affairs be allowed to go on unnoticed ? If so, how long ? I think we must wake up and start remedial measures, as truly speaking by this method of teaching we are preparing early graves for our daughters. I find, with regret, that even in big conferences not one thought is given to the sanitary requirements of girls' schools. The seal of silence ought to be broken, for if it goes on in this way, we shall repent at a time when it is too late, and our efforts and solicitude, will prove useless and abortive. A few girls' schools have lately been built by different communities who deserve our thanks, but in sanitary requirements they are as imperfect as any thing in the world can be. Paucity of funds might be pleaded by the supporters of these schools. Ostensibly there seems to be some force in this argument as well as in the fact, that something is better than nothing, but if this argument be weighed a little patiently, and measured by the standard of prudence, its fallaciousness is apparent at once. The fatal consequences which result from such education far outweigh the advantages to be gained therefrom.

I presume that the girls' schools in other towns of the Punjab are not in a better condition than those at Amritsar. The total number of girls in schools in the Punjab is estimated at 50,000, and is daily increasing, this makes it all the more incumbent upon us to reduce the evil, and remedy the defects.

I may also mention here that to keep the body in a healthy condition, some daily exercise is absolutely necessary. Boys have playgrounds, but girls are gener-

ally unprovided for. The same amount of labour is expected from them as from boys in reading and in passing the examinations, but there are no safeguards in the way of recreation provided for girls to maintain their health. The custom of the country and the social rules may prohibit indulgence in certain kinds of games, but give them their substitutes. It is deplorable that girls should share equal strain, but unequal rest and recreation.

Coming to boys' schools I find that in Amritsar, and similarly in other cities with a very few exceptions, the schools are held in hired premises. As far as their sanitation is concerned, they are situated in dirty lanes, full of offensive smell. The rooms are without sufficient light or air, are ill-ventilated, and in measurement about 10′ × 10′ each. There is no ventilation if you close the doors and abundance of draughts if you open them. In summer the heat is oppressive, in winter they are bitterly cold. With massive punkhas to be drawn four at a time by one coolie, backless benches to tire and fatigue the students, the walls and desks covered with dust, dirty window-panes, glazed and small lettered maps, the woodwork made filthy by boys emptying their noses, the verandahs used as spittoons, both by teachers and students,—such are the places where the boys get education. In the compound a licensed confectioner spreads his sweets, prepared of adulterated ghee, never tested by any medical authority, never seen whether stale or fresh : swarming with flies and wasps, and with no gauze sheet to cover them. The position of latrines is often extremely obnoxious and disagreeable. Either they are on the upper roof, or not very far off from the teaching portion of the school premises, the largest number being 3 to 4 separated by a partition wall. They are full of dreadfully obnoxious smells, and a visit there gives one a severe headache.

There are no urinals in the strict sense of the word and the whole courtyard is used for this purpose. Such as there are have no outlet for urine, and when flushed with water, perhaps once in a month, water and urine both soak into the ground.

The boarding-houses attached to some schools, or even those which are hired in a different quarter of the city, do not impress one favourably. They are not under the management of a medical officer, but that of a teacher, to whom a monthly allowance of Rs. 5 or so is granted. No arrangements exist for the boys to bathe every day, and the kitchens are full of flies. Few schools under the reform scheme have had the privilege of possessing dual desks, in most of the schools the students of lower classes have to sit on the floor on worn out mattings and *tappaes* full of gnats and bugs. The upper classes have benches which affect their chests, eyesight, lungs and backs. It is under these conditions that our children, the future support of our old age, the flower of our country, receive education, including lessons in Geography which necessitate reference every minute of the hour to small typed glazed maps, with nobody to tell the defects of the constitution and flaws of the different organs of the body, none to attend to their tired eyes and weakened sight, none to point out the disorders of the stomach and enlarged spleen, none to give lessons in the rudimentary principles of hygiene and sanitation.

What is the result of all this ? Only that in the majority of cases as soon as a student passes his matriculation examination, he has to wear spectacles, he complains daily of constipation and irregularity of the bowels, which end in chronic dyspepsia and many other symptoms of lowered vitality. At the age of twenty when there should be all-round cheerfulness, activity and hilarity, we find lassitude, and signs of anæmia. The student does not enter his profession or vocation in life with vigour, but under the sheer necessity of earning a livelihood and lives a miserable life with miserable health. Many at an early age become victims to tuberculosis, which has lately proved to be a deadly enemy of students.

I do not overlook or under-estimate what the Government and the educational authorities are doing to lessen the evils by awarding grants and otherwise promoting the means of health, and improving the sanitation of schools. We are specially thankful to the Imperial Government and the Punjab Government for liberally sanctioning building grants and grants for furniture, and for awarding medals and prizes to those who prove efficient in games, but our needs are great now and will grow more, when, under the new scheme, more primary schools are established specially for the sons of the poor. There will be more necessity for the sanitary safeguards for those boys, as poverty generally gives less vitality to bear the strain of education. In spite of all the parental care of the Government, I can say that, with the exception of European schools and a few Indian schools, the majority of our boys' and girls' schools, whether primary or secondary, are far from being on a fitting level with the present scientific requirements. The education imparted in European schools puts life into boys and girls both mentally and physically. Their faces and energies show that they are educated in a very healthy atmosphere. They must serve as ideals and object-lessons to us.

Having dealt so far with the insanitary condition of schools, I proceed to make some suggestions which may be considered by the educational authorities as fit for adoption :—

1. That the site for the school building should as a rule be approved by the sanitary engineer, or the medical officer of the district.

2. That the plan of the building as to the aspect of the light and air should also be subject to the approval of the medical officer.

3. That in the staff there should be at least one or two medical men to give lessons in hygiene, and with the help of the magic lantern to demonstrate to the students the different organs of the body, their formation and function, and the consequences of their abuse.

4. That periodically there should be medical inspection of the boys in relation to their eyesight, disorders of the stomach, chest, and lungs, and where means permit, such a medical officer should be a whole-time member of the staff.

5. That all the woodwork, such as doors, desks, boards and windows should be periodically washed with hot water and soap, and thoroughly disinfected.

6. That there should be a sufficient number of pails and closets, in proportion to the number of students, and that they should be daily washed twice. It is imperatively necessary to have a pucca floor in the latrines, and a good outlet for the urine.

7. That the confectioner in school should keep the sweets under a gauze cover, the sweets should be tested from time to time, by the medical member of the staff.

8. That the use of slates should be discontinued. Tongue licking of slates is not uncommon, and their use by one suffering from a certain disease can often give that disease to another. They may thus become a source of infection.

9. Glazed maps and pattis should not find a place in schools, as the small lettering is a great strain on the eyes.

10. Small-typed books should also be discontinued.

11. Dual desks should be introduced into schools. The boys of lower classes should also sit on benches, as damp floors make the younger boys ill.

12. That schools should be washed daily and a register kept showing that this has been done.

13. That boys suffering from enlargement of the spleen or infectious ailments, should be segregated, if there is a special provision for this purpose in schools.

14. If possible, dirty boys should not be allowed to mix with other boys. Cleanly habits can be produced, by persuasion and award of prizes.

15. That the students should be made to bathe daily, and some marks should be allowed in the examination for the observance of this rule.

16. That every student should take part in some kind of daily exercise, and the teachers should mix more with them, during the hours of games.

17. That a moderate amount of work should be given as a home task.

18. A student should not work for more than a definite number of hours, and should not sleep for less than a certain period.

19. That the subject of hygiene should form a part of the matriculation examination as well as the house examinations.

20. That the amount of grant should depend (partly) upon the observance of the above rules. Any neglect on the part of a school should make it liable to forfeit the grant.

1. As regards girls' schools:—That medical inspection as to general health by a lady doctor should be enforced, and a register kept in every school, showing the result of such inspections.

2. That well-ventilated and good spacious houses should be rented for girls' schools, and in no case should any girl be made to sit on the floor or read in the lowest storey of the house.

3. That habits of cleanliness should be insisted on, and primary books dealing with rudimentary principles of hygiene in story form, should be introduced.

4. That some kind of exercise should also be given to girls suitable to their needs, and consistent with the custom of the country.

5. That any thing which may produce discomfort and irritation should be absent from school, such as over-colouring of the walls and incongruous mixing of the colours, such things exert a depressing influence upon the minds of children. The interiors of the schools should be cheerful and there should be something pleasant to look at.

There is a great advantage in the medical inspection of schools. The future depends upon the healthy bringing-up of the children; the mere imparting of education is not all or the first thing that is required. We must have well-situated well-lighted and ventilated schools, properly dusted and drained, of cheerful appearance and with every necessary appliance for cleanliness, improvement of health and physical development. We must have in every school a teacher to supervise mental and corporal growth. We must always be on the watch to see that education is not imparted at the expense of good health. I do not mean for a moment that our schools should be converted into medical rooms, or the rooms of a hospital, or that instead of a teacher there should be a Hospital Assistant, but what I mean

is, that education should be given on healthy lines, that there should be some one to acquaint students with what human beings are, how they can preserve their faculties and make the best use of the different organs, so that on leaving school with education, they should also be in possession and enjoyment of good and strong constitutions, unimpaired in health, full of vigour, to perform and carry out the mission of life, with happiness and cheerfulness.

Much more help from Government is needed, and I can confidently say, that an extremely improved condition can be produced, if people co-operate with Government, modify a little their habits, and render assistance to achieve the desired end.

EDUCATION OF TEACHERS AND CHILDREN IN HYGIENE.

BY

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IT is obvious that before the children are educated in hygiene one must educate their teachers, so that this is the first part of the subject that will be dealt with.

In Indian schools it is usual to give 6 weeks' holiday sometime during the months of July and August, and it is in these months, therefore, that we propose to assemble the teachers at some central large town and give them a course of instruction in elementary hygiene, which will last about one month, and which will be both theoretical and practical.

In the North-West Frontier Province it is proposed to institute a special class for the instruction in hygiene of selected teachers of Anglo-Vernacular (High and Middle) and of the Normal School, and the Deputy Sanitary Commissioner will be deputed each year to deliver such a course of lectures.

The course will consist of about a dozen lectures and special attention will be paid to practical demonstrations.

The course will include instruction in :—

Water Supply and its storage ; soil and drainage ; air and ventilation ; food supplies with special reference to milk; meat, etc., and flies. Refuse and its disposal.

Latrines and conservancy in general.

Epidemic diseases, their causation, mode of spread ; and methods of prevention of the most common preventable diseases, such as:—

Malaria.
Cholera.
Plague.
Small-pox (including vaccination).
Tuberculosis.

In addition to this the commoner diseases met with in school life will be dealt with.

At the completion of the course an examination will be held by a Board consisting of the Chief Medical Officer, Director of Public Instruction and a Civil Surgeon, and special allowances, according to the degree of proficiency which they obtain, will be granted to successful candidates. The allowances suggested are Rs. 5 and Rs. 2 per mensem.

In the smaller provinces, such as the North-West Frontier Province, the Deputy Sanitary Commissioner can give the lectures himself at some educational centre; in other Provinces there is no reason why certain approved Health Officers should not do so.

The cost to Government would sooner or later be amply repaid by the increase of knowledge amongst the people. The present educated classes of Indians are in many cases too apathetic towards sanitary reform, if not actually hostile to it, to be of much use to us in educating the masses.

Summarising, you must assemble your teachers at some central place during the summer months of July and August, instruct them practically and theoretically and examine them, and sooner or later make it compulsory for all to have a certificate of having satisfactorily attended such a course and passed the prescribed examination.

I strongly deprecate any attempt at imposing a "text-book" upon children unless it be of the nature of a story tale. The instruction should be given, in my opinion, verbatim, and practical illustrations shown at the same time by one of these certificated teachers.

I would submit that children tend to learn off a text-book by heart and do not think about what it means; whereas if the instruction be practical this cannot be, and a more lasting impression will be obtained.

If we can only teach the "young idea" something about the rudiments of ordinary Indian sanitation we shall have inserted the thin edge of the wedge, and some day the millennium may occur when Municipal bye-laws will be but by-words of a forgotten age.

It is only by educating the masses that we shall be able to make any headway against preventable disease in India, the old methods of partially enforcing bye-laws, the reasons for which few or none understand, together with prosecutions, persecutions and fines, are useless and should cease.

THE PREVALENCE OF FLIES IN DELHI AND THEIR REDUCTION.

BY

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WHEN Delhi became the new Capital of India, it was a corollary that a big all-embracing sanitary campaign would take place. The new Capital could not be set up in unpleasant adjacency to a city in which sanitation was conspicuous by its absence and such old Delhi was. In most walled cities there is little tendency to expansion outside the walls; Delhi was no exception to the rule and increase of population had resulted in much overcrowding with all its attendant evils. Side by side then with the planning of the new Imperial Delhi was inaugurated the work of cleansing the old Delhi, and in the campaign one of the main assaults had to be against the uncountable hosts of flies that seemed to find that city a most congenial resting place. The prevalence of flies in Delhi was undoubtedly a very marked feature of the insanitary condition of the city, and a short description of the methods adopted to get rid of this pest may be of interest. It is not proposed to discuss the subject in any scientific strain, but from a purely practical point of view to describe the work done, and the general results obtained. If the details appear too ample, I would emphasize that, in combating the fly plague, as, indeed, in all sanitary measures, it is attention to detail that plays the most important part.

2. When the task of cleansing Delhi was first begun, no organised campaign directed specially against flies was undertaken. To begin with, attention was concentrated wholly on improving the general methods of conservancy and co-ordinating the staff, so that quicker and more efficient removal of filth and refuse from the city to the trenching grounds might be secured. A certain amount of incineration of rubbish and filth on the spot within the city was done and more careful supervision was also exercised over the trenching grounds. It cannot be said however that any appreciable reduction in flies resulted for some time. They were extremely prevalent in July, August and September 1912, and the advent of the cold weather brought no improvement in its train. The evil was obviously too deep-rooted to be amenable to ordinary measures, and it became apparent that very vigorous action would be required to produce any appreciable result.

Previously it had been the custom to cart the rubbish and dump it in any convenient place outside the city. This had been stopped and fixed dumping grounds arranged for at a considerable distance. With the continuance of the fly pest it was decided to reduce the number of the dumping grounds still further. The old heaps of rubbish were set fire to, and allowed to burn themselves out. On the top of new rubbish not less than one foot of earth was deposited. Under these conditions it was soon found that in such places flies had ceased to breed. Similarly the trenching grounds received much more attention and gradually the flies disappeared from them. Flies are certainly not now brought from the trenching grounds to the city. Trenches 1½ ft. deep were used and into these never less, and as a rule never more, than one foot of earth was deposited over the filth, and well rammed down. Coincidently with the attention given to disposal in the earth, incineration was started at nearly all the collecting depôts and latrines in the city. At these places flies were formerly very prevalent; the latrines swarmed with them and the whole areas were huge breeding grounds. With the introduction of incineration at the latrines all the filth and a good deal of refuse was burned on the spot; quicker removal of what was not burned was made possible, and flies disappeared from the sites where incinerators were built.

3. In spite of the above measures flies still remained very prevalent and it was clear that they were breeding in the city, in stables, in cowsheds, in the back yards of houses, and in the narrow airless gullies. An organised campaign was therefore started against them on the lines of an anti-mosquito campaign. The

city was divided up into wards, and a map was made of each of these—14 in all. Each Ward Sanitary Inspector was instructed in the places where flies were likely to breed, both in and out of houses. He was shown their larvæ and eggs and shown how to search for them. Street by street, lane by lane, the city was systematically inspected and all breeding spots were marked on the maps.

The public generally, but especially the owners of private stables, were appealed to, to co-operate in the work in their houses, stables, serais, and yards. Full and simple instructions were published emphasizing the fact that accumulations of filth and rubbish were the commonest breeding places of flies and that the only means of exterminating them was to prevent their breeding. It was pointed out that where flies were present in any great numbers, their breeding place would not be far off; that the killing of adult flies would not affect their prevalence, seeing that one female fly can give birth to many millions of progeny in one month. It was also emphasized that flies were largely responsible for the high infantile mortality from intestinal diseases.

A special beldar was appointed to each ward to deal with the breeding places of flies, as they were marked down. This beldar had a hand-cart, a phawri, a drum, a pesterine, a sprinkling can and a brush. All heaps of rubbish in odd corners were cleared away, the ground dug up, levelled and pesterined. Similarly all other infested places were treated, being again visited if possible within four days and again pesterined. In every case each place was treated at least once a week. The result was that in no case were fly maggots discovered again on the ground so treated. Pesterine was freely used as it was found that it had a marked effect on the flies: they will not come near, and certainly will never breed on any spot which has been well sprinkled with it.

The general supervision of the whole work was carried out by the Ward Inspectors. These were directed to visit each fly lair discovered in their wards twice a week, having previously informed the occupier, if any, or his servant. If necessary, the place was to be treated, and an endeavour also made to get the occupier interested in the work. The inspector was accompanied by the anti-fly beldar with his implements and pesterine. The general public were advised to ask the aid of the department in getting rid of the flies from their places, and were instructed by the staff to help themselves, and shown how to do so. It was hoped that a definite day and hour of inspection twice a week, being set aside for each fly-infested place, the owner or occupier would gradually take an interest in the work and take a pride in having his place clean and free from fly breeding. In a measure, indeed this was the case.

Once a week (every Monday morning) a report was submitted to me by the circle inspector of the last week's work in his circle, the areas dealt with, how dealt with, and the results. From these reports much interesting information was received, and at the same time many difficulties were revealed.

The work started in the spring and has been pursued steadily throughout the hot weather and the rains. Particular attention was given to these districts where infant mortality was most marked.

4. I now come to the findings of this survey and the more particular measures which were adopted.

(*a*) It was noted that fly maggots were chiefly found in stables: of these there are 511 in Delhi, accommodating from 1 to 20 horses each. In connection with all stables it was ordered that litter must be removed daily or burned, and stable owners were strongly urged to have incinerators on the spot. Where the floors of stables were katcha it was advised that they should be levelled, paved, and adequately drained. It was also insisted that bedding should be changed entirely at least twice a week. It must be said that the owners in most cases paid attention to the instructions. Some got incinerators for the direct disposal of the refuse: several had their stables paved and properly drained: the remainder all levelled their yards, and had them properly cleaned and scraped daily; in every case pesterine was used. There was never any litter allowed to remain in any stable over 12 hours, and the bedding was entirely changed at least twice a week. It was remarkable how under these conditions the flies gradually disappeared altogether: they were starved out.

(*b*) Cowsheds were treated in much the same way as stables. The work here was more difficult as the people being poor did little to help themselves, but it was accomplished and 787 cowsheds and cow yards were dealt with. This number is large, but Delhi unfortunately still houses a very large number of cows and bullocks within its walls and suburbs: the number of cowsheds inside the walls alone is 660, and some of these accommodate as many as 25 cattle.

(*c*) It was insisted that manure for garden or agricultural purposes should never be stacked in any compound. It should never remain exposed for more than 4 days, as in this time flies cannot have time to hatch. After this it must be dug into the ground and have a covering of not less than one foot of earth. The inspec-

tion staff were ordered to instruct the public and induce them to co-operate in the work.

(*d*) Next to stables, food shops and the areas around and under the takhts in front of them were found to be the most fertile fly-breeding grounds. In fact, these are probably the only places in Delhi where flies are to be found breeding now. Halwais' shops are worst of all, then butchers' shops and after them those of fruit and vegetable sellers. All shopkeepers were requested to provide dust-bins for the direct reception of refuse and to have the fronts and surroundings of their shops scraped daily, the foul earth removed and the ground sprinkled occasionally with pesterine—say twice a week. Work is persistently going on in digging up these katcha dirty areas and purifying them. The shopkeepers, who at first objected to the sweepers attending to this work, have at last been induced to do it themselves, but a great many prosecutions were necessary. Until the flooring of all such shops is made pucca throughout with adequate drainage, pucca fronts and pavements they must be a constant source of trouble, the ground being habitually saturated with an excellent pabulum for the birth of the fly, which, hatching out, has its nourishment close at hand.

(*e*) Another fertile source of flies was the private house latrines. Great numbers of these were closed altogether and the people as far as possible induced to use the public ones. In other cases pucca floors and drains were insisted on and a very large number were made comparatively sanitary in this respect. The work however was not carried out without a large number of prosecutions.

(*f*) Khandars or sites of ruined and tumble-down buildings were found to be a fertile source of flies as people often prefer them to latrines, and also use them as dust-bins. Many notices were therefore issued, and, eventually with the aid of the staff, the khandars were all cleaned up and levelled. There was a great deal of trouble over such places. As they were abandoned sites, the owners paid no heed to them. It was the usual thing, apathy and obstinacy on the part of the owners against any improvement, however small. Complete lists of such places were made and they were inspected subsequently as "places under suspicion."

(*g*) As the work went on, it was observed that in the wards where katcha houses were most common, there the flies were most difficult to cope with. The open parnalas running down these katcha walls, soak the walls and bases of the houses which are permanent fly-breeding spots and most difficult to deal with. Wherever collections of katcha houses are, there must always be flies breeding in and about the walls, and the only remedy for this would seem to be wholesale demolition and the erection of pucca buildings.

(*h*) While the above measures were being put into operation, increased attention was paid to the collection and disposal of filth and refuse.

The site of each collecting depôt or dalao and its surroundings is scraped clean daily, and pesterine is well sprinkled over it twice a week (on Wednesday and Saturday mornings). Dalaos not paved are all being paved. As much as possible of the rubbish is shot straight into the incinerators, which are kept constantly working, the remainder is deposited direct into the carts and not on the ground, carts so soon as filled are removed and are not permitted to pass through the streets uncovered.

The conservancy superintendent has been made responsible that, on the arrival of the night-soil carts at the trenching grounds the filth is immediately trenched and covered over with not less than 1 foot of earth. Likewise, all rubbish brought to the dumping grounds has to be set on fire if it will burn, otherwise, spread out and covered over with earth as above. It is difficult to get enough earth to cover up all the rubbish, but it was found by keeping it burning in heaps, fly-breeding was prevented. Litter is never dumped, it is all burned up at once in the incinerator near its origin.

5. The above campaign has not been carried out without meeting a good many difficulties. Chief of these was at first the opposition and apathy of the people. Many of the worst fly-breeding places were in the back yards and the house owners objected to the entrance of the beldars and sweepers. As the result of the work became more obvious, however, the co-operation of the people in the movement began to manifest itself and latterly, though it fell far short of what I should have liked to see, it was certainly much more than I expected in the first year.

One point noted especially in this campaign was that many of the customary sweepers lived a long way from the places for the cleanliness of which they were responsible. A redistribution had to be attempted by which each sweeper might have a compact set of houses, etc., which he could look after conveniently. This redistribution was only very partially successful as it was, of course, breaking into an immemorial custom.

6. The campaign had to be largely one of persuasion, and the different measures described only came into operation more or less gradually. The diminution in the prevalence of flies was a gradual process also. Making all due allowance for the seasons when ordinarily flies are most in evidence, the process of reduction

has been a steady one with the exception of two breaks. The first of these lasted for one week in June and seemed to correspond to a cessation of rain some 10 days before. The temperature then was most favourable to the hatching out of flies, *viz.*, about 95° or 98° F. These flies were undoubtedly hatched out in the khandars. They were not hatched in stables, nor were they from observation hatched at the trenching grounds. This prevalence did not last, the following week's reports show a marked decrease. The flies were not progressively multiplying, and the adult fly was probably starved out: it was becoming more and more difficult for the female to find a suitable place to lay her eggs, and if she did lay them, they were promptly disposed off. It may be noted that, although the temperature conditions in August were very favourable, a rapid decrease in prevalence took place in this month.

Flies continued very little in evidence till towards the end of October and then curiously enough coincidentally with the Dewali festival the second (a double) wave of prevalence occurred. This festival is the "annual spring cleaning" of all the Hindu houses in the City, and from about the 15th to 25th October flies were fairly prevalent. The day temperature at this time was very favourable to the hatching out of flies and it seems to me perfectly clear that the cleaning of houses whereby large quantities of rubbish holding clumps of eggs and larvæ were thrown out into the open under favourable conditions for rapid metamorphosis, accounted for this. Between the 25th October and the 2nd November approximately there was a lull in breeding: then suddenly for the week ending 8th November there was distinctly increased prevalence. This second wave corresponds roughly to some 10 days after the Dewali, and indicates, I think, the flies hatched out from eggs deposited in the rubbish cleared out of houses during that festival. Much extra work was of course thrown on the conservancy staff during the festival, and it was impossible to effect a thorough removal and several breeding places also were sure to have been overlooked.

The sudden prevalence was soon over, and up to the end of November flies have continued in greatly decreased numbers. The people in the city, both Europeans and Indians, have repeatedly acknowledged to me the vast improvement that has been effected and expressed their gratitude for the increased comfort that has resulted.

7. In an anti-fly campaign incineration plays no small part, and as practised in Delhi has, in my opinion, been a distinct success.

The type of incinerator used is that known as the Sialkot pattern. There are also three large open iron ones, of the Raitt pattern, outside the walls. For private use small iron incinerators of a closed-in pattern are the most common, but at certain of the mills, serais and stables, the Sialkot pattern has also been put up privately, and is in use.

The primary object of the incinerator is to consume all the night-soil of the public latrines, and for this purpose they are built close to the latter. There is difficulty in the application of incineration to all filth on account of the manner in which the private sweepers bring it to the collecting depôt, *i.e.*, mixed with earth and ashes. However the incinerators at each depôt, I find, burn all the filth taken direct from the latrine at the depôt and all the burnable refuse brought there. At present over one-third of the entire filth and refuse from the city is disposed of by the incinerators, and the erection of more is steadily going on. This greatly reduces the cartage and allows of speedy removal. Accumulation of materials at these depôts with consequent constant fouling of the site and breeding of flies is thus avoided. Material not burnable is placed direct in the carts which when full are at once removed. No accumulation of refuse is ever permitted on the site which is either pucca or cleanly swept, and in all cases regularly sprayed with pesterine.

It is not an agreeable sight to see carts full of refuse even if covered traversing the streets during the day, but it is unavoidable as the private sweeper will never collect the night-soil and bring it to the collecting depôts early in the morning. In the cold weather his favourite hour is about 10 A.M. and no efforts, rules, regulations, or prosecutions will alter his habits. It is better for him to bring it when he can, than let it accumulate for hours or even days in the house or back-yard, providing excellent fly-breeding lairs. Incineration however reduces this cartage very considerably.

For incineration there is no fuel so efficient as litter; it burns slowly and produces complete incineration of the night-soil. A well loaded incinerator will also take without detriment to its working, if judiciously deposited, all the urine of the latrine it is attached to, though in most cases in Delhi this is drained away to an existing underground sewer.

A point which should not be lost sight of in incineration is that one can do away greatly with the use of disinfectants. An incinerator is a large disinfectant in itself. In such diseases as cholera, enteric, etc., incineration of excreta on the spot has a double effect: it prevents the breeding of flies to hang about the latrines

and carry infection elsewhere, and it gives prompt treatment to any infected stools. In the rains incineration presents no great difficulties if a shed divided into two compartments is attached to each incinerator and kept full of dry litter to be used from each compartment alternately. The accumulation does not give rise to fly-breeding as it is always being changed, at the outside it is changed once a week, and, of course, the place is always under supervision.

8. Quite apart from its being an intolerable and disgusting nuisance, the importance of the domestic fly as an agent in the dissemination of disease, particularly those of the intestinal tract such as cholera, enteric, dysentery, etc., cannot be exaggerated. The literature on the subject is very large and well-known and it is unnecessary for me to refer to it here. One disease, however, infantile enteritis, is recognised to be in great measure caused by flies and is of special importance as being the chief contributor to the very high infantile mortality in Delhi. Judging by the results on the infantile mortality the anti-fly campaign has not been without effect, in August of this year it was 333 against 363 for the same month in 1912, in September 242 against 409, in October 222 against 444, and in November 185 against 415.

My experience in Delhi, a notoriously fly-infested city, has shown me that, so far as that experience has gone, it is not a difficult matter to reduce the number of flies if the work is systematically carried out, and naturally the amount of disease conveyed by these insects is bound to be diminished. The results have certainly been encouraging, but it is a campaign which must go on ceaselessly. It is a permanent work. The great difficulty is the want of co-operation by the public. If the public could be induced to take an interest and co-operate in the work of the sanitary staff, the reduction of flies would be a very easy matter indeed.

9. Full conclusions cannot as yet be drawn as to the ultimate success of this experiment in fly reduction, but the fact remains that flies were enormously reduced in Delhi this summer and autumn, and the statistics of infantile mortality give strong evidence in its favour. Climate may have had a good deal to do with the reduction, but in the months of July and August, when the climatic conditions were at their very best for flies, these were much less prevalent. The campaign still goes on. Next year it will be on more specialised lines and will commence seriously as soon as the first hint appears that the days are becoming warmer.

PAIL LATRINES AND A PLEA FOR THE SWEEPER.

BY

MR. GEO. P. ROBERTSON,

Municipal Engineer, Darjeeling.

THE Pail latrine is a structure of great importance in Indian sanitation and as the types put up for sale in India are often very unsatisfactory, I propose giving the result of my experience in the hope that the matter will be fully discussed and an efficient standard type evolved.

The great objection to most existing types is that little consideration is given to the sweeper. The seats and the structure have angles and crannies which make the place very difficult to clean and the consequence is, that either the place is not cleaned properly or the cost of cleaning becomes excessive.

A well designed latrine should have nothing to obstruct the progress of the sweeper's broom ; it should have no angles or crannies into which filth can collect ; it should have no pit or non-portable receptacle for urine ; it should allow of the solids and liquids being separately removed ; it should have easy access for the sweeper ; it should have plenty of room for the sweeper to do his work ; it should have a ventilation area, if possible, in excess of the area of the screens ; it should be close to the dwellings of those who are to use it and the approach paths should be well made and kept free from jungle.

The problem is simplified in a place like Darjeeling where there is no difficulty as to gradient and where there is an ample water-supply, because the urine can there be got rid of by automatically flushing it into the surface drains. The type of latrine adopted in Darjeeling has squatting plates of concrete which overhang the pails. The screens for these plates are of plain galvanised iron sheet, curved round the backs of the plates so as to overhang the pails. There is no leg or standard, from plate or screen, to obstruct the pail floor, so that this can be swept clean from end to end without difficulty. The pail floor is sloped towards a low wall from which the squatting plates project and a drain is formed at the junction of floor and wall. The pail, when placed in position, is tilted by the slope of its floor towards the wall into the most effective position with regard to the squatting plates.

A drain is run along the front of the squatting plates and shallow channels are formed in these plates for the passage of urine to the drain. The floor of the passage way in front of the seats is sloped towards the same drain so that the whole place can easily be washed down. The roof is of corrugated iron on a single slight slope ; it only just covers the squatting plate screens and falls short of the back screen so that rain and sunlight get to the pail floor.

An automatic flusher is placed at one end of the row of squatting plates and the flush travels first along the drain in front of the plates, then reverses its direction down a steep channel to the pail floor drain, along which it passes and then discharges to an outside surface drain. Standpipes are fitted inside the latrine so that the floors can be washed down with the help of a piece of flexible hose.

Plan A shews this latrine and Plan B gives details of the automatic flusher.

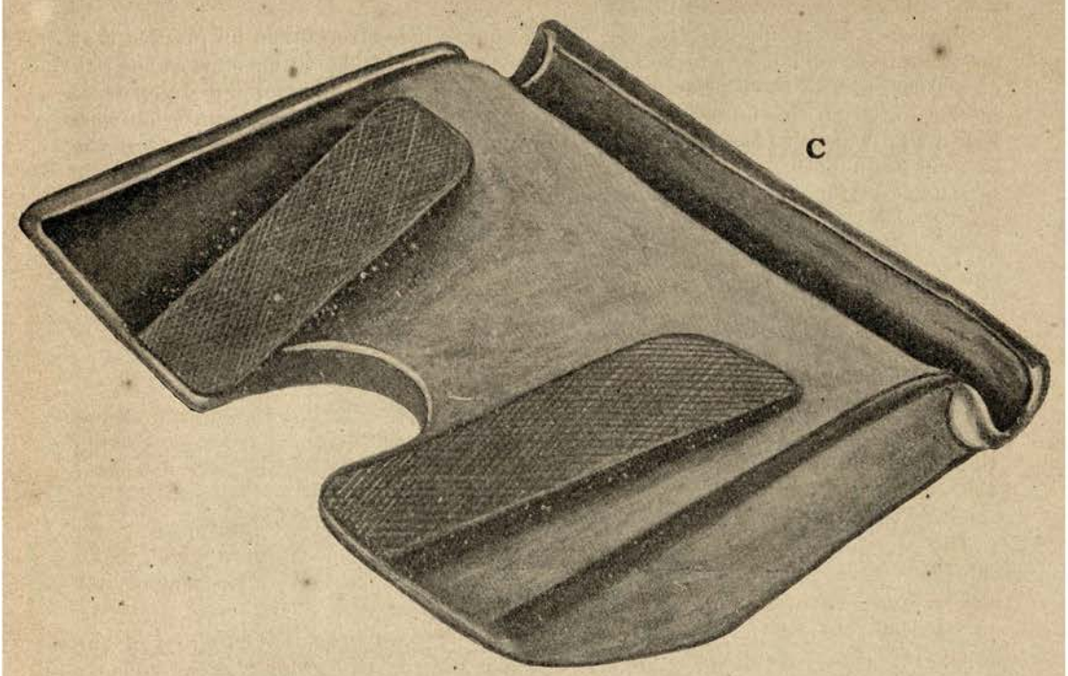
The cost of such a latrine, in Darjeeling, erected complete with flusher, is—

Rs.	60	...	...	...	...	for one seat.
,,	110	...	...	...	...	,, two seats.
,,	150	...	...	...	...	,, three ,,
,,	190	...	...	...	...	,, four ,,
,,	230	...	...	...	...	,, five ,,

and Rs. 44 per seat for everything, over five seats.

Photo. C shews a squatting plate of glazed stoneware for this type of latrine. This plate has the urine drain attached to it, the underside of the drain is of dovetail section so that it will key into the concrete floor and resist the tendency to tilt over

with the weight of the person squatting on the plate. The screens and roof may be made of ferro-concrete if a permanent structure is required or they may be of bamboo mats if the latrine is required for temporary use.



The pail in use for these latrines was designed by Dr. C. B. Seal of Darjeeling to simplify the work of the sweeper. The body is blocked out of one piece of steel sheet and it has a rounded bottom, so is very easily cleaned. In the latest type the handles and foot ring are spot welded into position and the whole galvanised. The cost of a 12″ pail of this type is Rs. 4 each, complete with lid. The lid at present in use is of the common pot lid type and not very satisfactory, but I am in correspondence with the manufacturer for the supply of a simple cover to fit outside the rim of the pail.

No matter how well a pail latrine is designed it will become a source of nuisance if not efficiently handled.

I have found that the cause of most of the bad smells from the latrines is the emptying of one pail into another by the sweeper employed to remove the excreta. This is done because some householders object to maintain a duplicate set of pails and the sweepers try to avoid having to carry a large number of pails, but the practice is a most objectionable one and to kill it in Darjeeling we have arranged to supply all private latrines with free pails ; the latrine tax being slightly increased to cover the cost. These pails are supplied in duplicate to each latrine, one set being painted black and the other red. Every time a latrine is cleaned, each pail in it, whether foul or clean, is taken from it to the nearest chute and replaced by a clean pail of the other colour. Pails brought from a latrine are immediately cleaned and stacked in the chute chamber when they are ready for next day's work. If pails of different colours are found in any latrine or chute by any Inspecting Officer the head jamadar, responsible for that section of the town, is fined.

The chutes used in Darjeeling are simply large water closets, placed at convenient intervals throughout the town and connected by pipes to septic tanks. All public latrines are connected and most of these have chutes attached to them.

The nuisance caused by the filling up of pails with night-soil does not end at the latrine ; the carriage of full pails from the latrine to the chute and the emptying of large lots of night-soil into the chute are also sources of offence.

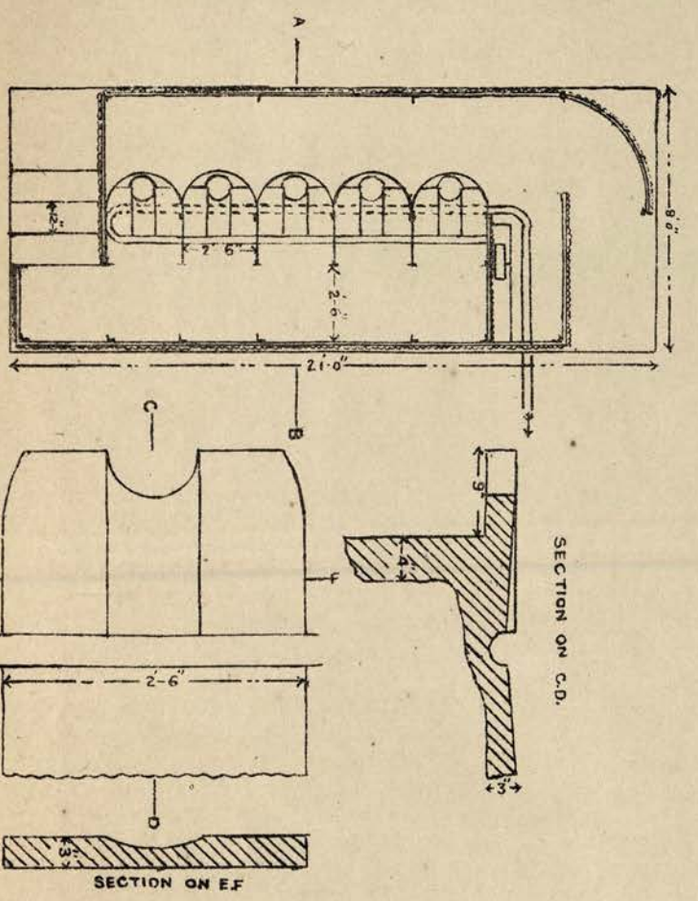
The average pail in a Darjeeling latrine serves about four users a day, so, if nothing is emptied into it by the sweeper and if the contents are washed into the chute with a voluminous supply of water, there is no offence whatever.

Where this system can be adopted the pail lid need not be made to fit air-tight; it may be formed as a simple and easily cleanable dish-shaped cover fitting loosely over the mouth of the pail.

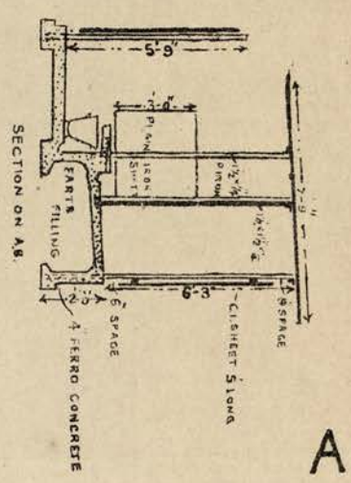
Where the latrine is an outside one the path for the user is often so bad that he uses it as a latrine rather than proceed along it. It is therefore important that the approach path should be at least four feet wide and that it should have a good surface and be kept clear of jungle. The latrines should, however, be placed as close as possible to the dwellings of those for whose use they are intended, otherwise the roadsides will be used in preference to them. This is not altogether because of the distance the user has to walk but also because, when the latrine is not close to the dwellings, it

is liable to neglect and may become so filthy that people will go anywhere rather than into it. Where the latrine is close to the dwellings the occupants of those dwellings very soon complain if the latrine becomes offensive and it is, as a rule, more used and better cleaned than when at a distance.

Where a path is intended for the sweeper only, it is often taken for granted that anything is good enough and he has sometimes to scramble to his pails at the risk of his neck. The same principle, that anything is good enough for a sweeper, is made to apply to his house, his food, his clothes and everything in connection with him, but if we are to have good sanitation we must make up our minds to treat the sweeper as an intelligent human being and as a man who will respond to sympathetic treatment. If he is properly housed and cared for he has a better chance to keep in good health and so is more fit for his work and less liable to carry infection; if his work is simplified he can do more of it, so that not only is it the right thing to treat him well, but it pays.



ENLARGED VIEW OF SEAT
SCALE 1" = 1 FOOT



DARJEELING TYPE
PAIL LATRINE
SCALE 4' =

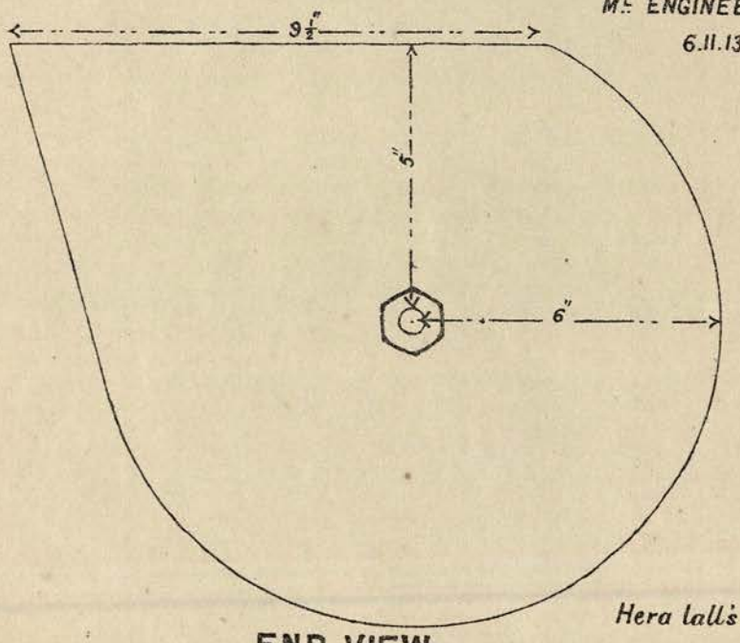
Geo. P. Robertson
M.I. ENGINEER
30.1.10

TILTER

Scale ¼ Full Size

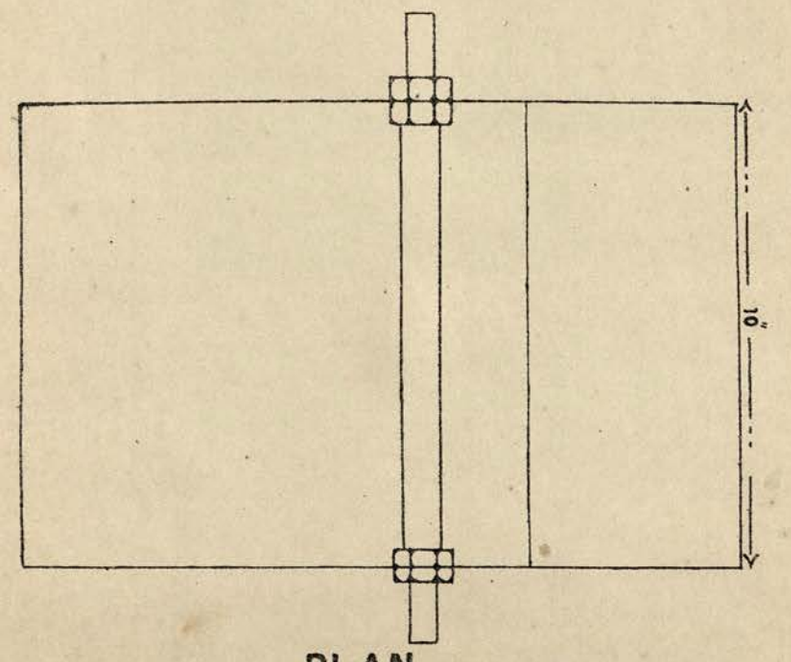
Ges. P. Robertson
M.L. ENGINEER
6.11.13

B



Hera lall's type

END VIEW



PLAN

NOTE ON THE NASIK SYSTEM OF PITTING NIGHT-SOIL TO RIPEN IT FOR SALE TO CULTIVATORS.

BY

MAJOR J. L. MARJORIBANKS, M.D., D.P.H., I.M.S.

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THE system which is the subject of this note has not, properly speaking, the right to any specific name, as it has no one feature which is original, but the phrase "Nasik System" having been used by enquirers who have written to Nasik to ask for details, it has been found a convenient one to adopt. In the opinion of the writer it is mainly worth calling a "System" at all because he has found it, after two or three years' observation, to be a method of locking up the nitrogen of a town in one year, to prepare it for economic use the next year, which can be carried on all the year round without giving rise to objectionable smell, and without breeding flies.

Till fairly recently, the night-soil of Nasik, a municipality of some 30,000 inhabitants which has not yet a water carriage system, was made into poudrette by mixing it with the ashes of town sweepings. This method, which had been used for many years, was finally given up in consequence of the protests of the Sanitary Department, as the poudrette farm was so infested with flies. Another method for the disposal of night-soil had accordingly to be arranged for. Incineration was given a good trial. But the night-soil of a town in the West of India with a large proportion of high-caste inhabitants is a very fluid product, containing a large amount of ablution-water, and its incorporation with rubbish to form a combustible mixture was found much too laborious to carry out. Trenching was not to be thought of. Its essential feature, the immediate application of the night-soil to the superficial and bacteria-bearing layers of the soil, is open to the fatal objection that the night-soil is there exposed to the attentions of flies, especially in the monsoon months; it has deservedly been condemned by military experience.

It was accordingly resolved to have recourse to some improved form of the old native practice of pitting.

This in its simplest form consists in shovelling the night-soil into a perfunctorily dug hole. The regularly shaped pits which were dug at Nasik were such as would be called trenches, were it not for the necessity of distinguishing the method from that already known as "trenching." As seems always to be done when experiments in pitting are undertaken, an attempt was made at first to cover the night-soil with earth, but this sank at once to the bottom of the liquid. An attempt was then made to float the earth on a layer of *kachra*, *i.e.*, town sweepings, on top of the night-soil. But in practice the *kachra* was found itself to make such an efficient air-seal and fly-seal, that the use of earth, which only tumbles through into the night-soil and dilutes it, was given up.

Kachra alone, then, is used to cover in the pits at Nasik. The town, being one with the railway station several miles away, has a good tonga service, and this means a high proportion of grass in the Municipal *kachra*, which renders it particularly suitable for the purpose of sealing the night-soil pits.

Fermentation does not cease at once when a pit is sealed, and as the gases cannot diffuse through the layer of *kachra* the latter bursts in one or two places during the first day or two, little lava-like eruptions of gas and night-soil taking place locally. These are easily patched with fresh *kachra*.

The air-tightness of the seal has one temporary drawback, that it retards the drying of the night-soil. Weeks after a pit has been closed, in the dry season, the contents, if it is opened, may be found quite wet. But drying does occur, and ripening takes place, though slowly, and the wet period has this advantage, that it prevents the development of maggots from eggs already laid in the night-soil before it reaches the pits. The writer has only once seen maggots in a pit when a number were tested by opening them several weeks after they had been filled. This pit was fairly dry. The contents of the surrounding pits were still quite wet, and none showed any maggots. The air-sealing of this pit had evidently been defective.

It is very remarkable how the efficient sealing of a pit stops the smell from it and its consequent attractiveness to flies. The Nasik depôt is a very inoffensive place to visit at any time of year.

Heavy rain in no way interferes with the management of a system which treats night-soil to start with as a liquid. Nor does the presence of an unusually large amount of fluid in the carts. The appearance of an extra cartful of urine from the latrines causes no embarrassment; in the case of an incinerating plant it would be a distinct temptation to irregular practices!

The fact that fluids are disposed of in the pits makes them shrink as the contents dry. This is of no consequence in the dry season, and in the monsoon extra *kachra* can be put on to prevent water from standing on them.

Properly speaking, each day should have its own pit, but it has been found to save labour to have some pits that will contain several days' night-soil. Each is sealed on the evening of each day on which it has been used.

One practical point has to be attended to if the pits are to be kept clean about the edges, with no spilling of night-soil to attract flies. A night-soil cart cannot be backed over a pit so that the valve gets properly over it. A trough open at one end should be made and kept at the depôt, to be placed underneath the valve, and to project into the pit.

The following is a useful form in which to convey instructions for the detailed working of the pits. If the sale of the product is to bring in the revenue it should, careful attention must be paid to the numbering and registering mentioned:—

1. The night-soil has to be protected from being eaten by birds and animals, and from having eggs deposited in it by flies.
2. It should not be mixed with earth. This does not prevent the development of maggots, and the dilution lowers its manurial market value, giving it a poor reputation with cultivators.
3. Wherever possible, ground near a nullah should be chosen for pits for the sake of the under-drainage.

The latter occurs best, of course, through a loose sub-soil, but there is this advantage in having the pits in a stiff soil that they will retain their shape, and can be used over and over again.

4. In a heavy soil the pits should not be more than two or three feet deep, or the night-soil will not dry. Moreover, in any soil, the labour of excavation is greatly increased by greater depth.
5. The pits are conveniently made up to five feet broad. Beyond this, the labour of covering them in becomes considerable.
6. The pits may be of any length, as municipal night-soil is so fluid, finding its level even in a pit 80 feet long. It should thus be only the *length* of the pit that is determined by the amount of night-soil to be stored on a given day.
7. As night-soil carts cannot be conveniently backed over a pit the depôt should be provided with a metal trough, open at one end, to be laid under the cart. The valve should be opened slowly.
8. When the day's night-soil is all in the pit, a layer of a few inches of *kachra* is lightly sprinkled on the top. The *kachra* floats and constitutes the seal of the pit. Flies are not found to be attracted to pits so sealed.
9. During the next day or two, and sometimes even later, there will, in a long pit, be here and there little volcanic eruptions of gas and night-soil through the *kachra*. The sweepers go round and patch these with a shovel full of *kachra*.
10. As the night-soil dries the level of the top of the pit sinks. This does not matter in the dry season, and the pit should be left for the action of the sun to complete the drying. But before and during the monsoon all the pits should be levelled up with extra *kachra*, as it is bad to allow rain-water to stand on them.
11. The earth originally excavated can be used to protect the sites of the pit from running rain-water, and it is better to make this use of it than to let it lie about in irregular mounds and ridges.
12. It may be found convenient to use one large pit for several successive days' night-soil. If this is done each day's night-soil is sealed with *kachra*, and the next day's is allowed to run on to the top of it.
13. The contents of a pit may shrink so much in drying that there is room for a day's night-soil on the top. This should never be applied, however, to a pit whose contents have only half dried.
14. Unlike systems for the immediate application of night-soil to the land, pitting can be carried on all the year round. The monsoon does not interfere with it, if the pits are dug several days ahead, a number of pits being dug at a time. It does not matter if these partly fill with water;

this only means that the night-soil will be diluted and will shrink more than ordinarily.

15. A register of the pits should be kept, with columns for dates of filling and emptying, and for remarks. Each pit should have its number painted in white upon black on a piece of metal fixed to a wooden peg, to be stuck in the ground, at the end of the pit away from the approach for the night-soil carts.

16. Night-soil is not ripened thoroughly much under a year, but a good deal depends upon the dryness at which it has been kept. The demand by cultivators for it begins in the cold weather and is at its height in the hot, ceasing in the rains.

17. Well-ripened night-soil looks extraordinarily like earth, though if inspected and smelt closely it is noticed to show grains of half-digested cereals and to have a faint odour, perceptible at about two inches.

NOTE ON THE PITTING OF NIGHT-SOIL AND MANURE IN PRIVATE COMPOUNDS.

BY

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IN places in which the compounds are not regularly visited by municipal sweepers it is quite common to find that the domestic sweeper removes the contents of the commodes to some field or nullah behind the house, his method of disposing of it there being merely that which gives him the least trouble. It is much better to pit the night-soil on the premises of a bungalow, if the compound is a fairly large one and if the pits can be so located that there is no fear of contamination of any well.

Even if the night-soil can be removed by municipal labour it has to remain for anything up to 24 hours on the premises, and if that in the servants' privy is reckoned too, this means a good deal of material for the attention of the family flies. The great thing about pitting is the rapidity with which all excrement can be hidden beyond their reach. There is the horse-dung from the stable to deal with also, which will breed eye-flies, and then crumble away and waste its nitrogen, if left exposed to the air. Where "pitting" is done in a compound every bit of excrement, of human beings, horses and cattle, should be buried in the same pit. The contents of the pit are dug up later on, and worked well into the vegetable beds, but, for chemical reasons, no pit should be opened which has not been closed for a year, or at least for a whole dry season.

It is convenient to have the pits of a cubit ("hath") or more in depth and breadth. They may be of any length, but should be cleanly rectangular. Several long ones, parallel to each other, are best dug at a time, as less fuss is made by a sweeper about having to dig once in a way than every day. A convenient locality is opposite the stable. The site of each pit should be marked out by four tarred pegs and a string before it is dug. The pegs should be well driven in, as they are needed to be permanent indicators; no one should be allowed to pull them out. The pegs should be pointed out to any incoming tenant.

A section of a pit should be used each day. The sweeper, the syces and the cow-herd should each bring his own stuff at his own time and drop it in, at the end of the pit that is being used. The excreta, including urine and the washing of commodes, can be easily and rapidly covered as they are put in, with stable litter from a heap that should be kept at hand. At night the day's accumulation should be well packed back by the sweeper, to occupy as little space as possible. A little waste grass should be laid on top, and the section levelled with earth. No mixing with earth should take place, as this only dilutes the manure.

To keep the place tidy and level the spare earth should not be left in heaps by the pits, but should be spread about elsewhere in the compound.

Though all the horse-dung goes in, the soiled stable grass is too bulky to bury. What is not used for covering in the excreta should be burnt in the pit, along with the contents of the wastepaper baskets.

Egg-shells, tea leaves, potato peelings, in fact, everything with which servants can make a compound untidy, can be buried in the pit, except broken bottles and tins.

To get the full value of the manure on the vegetable beds, when it is dug up, the lumps of which it is composed must be broken up by hand and scattered over the beds broadcast. This dried and ripened manure is perfectly inoffensive to handle. It is hardly necessary to mention that all pathogenic bacteria in it have long since perished.

The writer has found that there are only two practical difficulties to be overcome in making this method a success. One is the disinclination of sweepers to dig; this has to be conquered by firm insistence. The other is the disinclination of householders to take an interest in the sanitation of their compounds. The Brahmin who tells you that the reason why he does not need to keep a sweeper is because his neighbours' cows visit the back of his privy has his counterpart in the European,

equally scrupulous about personal cleanliness, but who could not tell you if you asked him what kind of receptacle is used in his servants' privy, or if any is used at all. Yet the servants' privy is the plague-spot of the average compound, from the point of view of intestinal diseases.

It is not a bad thing that the pitting system gives the master of the house a reason for keeping an eye on the state of the compound, and one advantage of it is that the system enables the servants' privy to be cleaned, not once, but several times a day.

The supervision of the system cannot very well be left to the mistress of the house. But by the next year she is very glad of its results, in the shape of the vegetables that are the outcome of it.

A SHORT NOTE ON INCINERATION IN INDIA.

BY

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I do not think that by means of incineration alone we shall be able to deal with all the refuse and night-soil met with in Indian large towns and cities, nor is such an attempt advisable on account of certain financial considerations.

For example what occurs in Peshawar City is as follows :—

There are some 20 antiquated Raitt pattern incinerators at work which consume possibly a quarter of the refuse, mostly street sweepings, etc. The remainder of the street refuse, night-soil and other débris is carried in open carts to what are designated "filth godowns." These are two in number and might best be described as small plots of land situated conveniently near the city for their presence to be 'felt' in summer and 'seen' in winter, where a wholesale dumping of the contents of the filth-carts, and all other forms of refuse, such as offal and blood from the slaughter-houses, etc., takes place during most hours of the day.

No effort is made to adapt the amount thus "disposed of" to the area of the land, it is simply left to rot away ; and in the meanwhile is picked over by the scum of the population assisted by an army of birds and dogs. After a certain, or uncertain, period of time this material is sold to zemindars and others as manure ; it is then "picked over" on the spot by the purchaser's minions, the useless material being thrown to one side, and the manurial portion taken away and very often dumped down in the most convenient spot outside the "filth godown," to be finally carted away when required.

It is the presence of these "filth godowns" that acts as a serious limitation to the employment of incineration because of the very large income earned by Municipalities through the disposal of this material, being often about $\frac{1}{10}$th of the entire income.

I had occasion recently to make enquiries regarding the opinion of a Municipal Committee regarding the location in the heart of the Municipality of a certain "offensive trade." One member of the Municipality informed his confrères that the Proprietor had obtained a certificate from a Medical Officer stating that the—"premises were maintained in a sanitary state, and that the carrying on of the trade caused no nuisance."

The Municipal Committee held that, whether it was sanitary or not, it was objectionable and must therefore be removed ; and so it is to be.

Here the Municipal Committee either separately, or as a whole, derived no financial benefit from the presence of the aforesaid trade and so there was no difficulty in their agreeing to its removal ; but, as before suggested, a municipality that is drawing a very considerable and easily earned income from this method of "disposal" of its refuse will be very loth to give up any portion of the same, whether the benefits derived from the same affect the sanitation of the place, and the salubrity of the inhabitants, or not.

These limitations do not affect a small self-contained community such as a military cantonment where supervision can better be carried out, and where the early disposal of the refuse is of the greatest importance ; the same applies to small frontier outposts where "trenching" is out of the question and where incineration often offers the only means of disposal of refuse.

Another limitation to the employment of incineration is the incombustible nature of the material. Apart from night-soil, the refuse of an Indian town consists of vegetable débris, tins, bricks, broken chatties, bottles and other incombustible matter, to which has to be added the excess of moisture present in the material in the rainy season.

Again, supposing that we have in use a satisfactory type of incinerator, the constant supervision that is required for really effective incineration is nearly always conspicuous by its absence.

As before remarked, I think that the greater part of the night-soil of a large city is best disposed of by some system of "trenching" rather than by incineration.

The possibilities of incinerators have been proved in Madras City and there too under comparatively unfavourable climatic conditions.

It is obvious that where there is land to reclaim, or pits, depressions, and low-lying insanitary areas to fill up, that the presence of an incinerator in the vicinity where the screened incombustible portion of the refuse can be easily and profitably got rid of, is of value. In the ordinary Indian town, or more correctly just outside, the land, whether low-lying or not, is not available for this purpose, and the owners would strongly resent use being made of "incineration" to raise its level by the deposition of the refuse that possessed a very poor manurial value.

Local climatic conditions are well suited for the installation of incineration in the North-West Frontier Province, and I think there is a great future for the same, once the Municipalities and people are educated up to the advantages to be obtained.

With regard to cost, there is no question that incineration is the cheapest sanitary method of disposal of refuse—a considerable saving being effected in the cost of cartage, feeding of bullocks, labour, etc.

I have not touched upon the question of the nuisance caused by smell, because such would seem to be superfluous in the case of an ordinary Indian town with its many and various fragrant odours ; but it has been urged that one of the disadvantages of life in an Indian Cantonment is the smell from the continuous smouldering of these "hygienic" fires. The impeachment must be admitted, especially in places that are low-lying, very much enclosed, or what is generally much more vitally concerned, considerably overstocked with trees which prevent the free interchange of air currents, and cause stagnation of these unsavoury clouds of smoke. The remedy here perhaps lies in the adoption of some sort of leaf or litter filter as recommended by Captain P. S. Lelean, R.A.M.C., in the *R. A. M. C. Journal* for October 1911 (Volume XVII, page 357).

Summarising, I would submit that incineration offers a cheap and fairly rapid method of disposal of refuse in smaller communities. A considerable saving is effected in cartage, hire and labour.

It can be most profitably carried out at certain spots where the incombustible débris and the ashes can be utilised to fill up insanitary depressions.

The chief drawbacks are :—

The amount of supervision required.

The difficulties of obtaining combustion in the rainy weather.

Possible loss of income to the Municipality.

PROPOSALS FOR THE FORMATION OF A WOMEN'S DOMESTIC SANITARY SERVICE FOR INDIA.

BY

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WE the Council of the Association of Medical Women in India at our 4th Annual Meeting, held at Delhi, January 3rd, 5th and 6th, 1914, have drawn up the following proposals for a Women's Domestic Sanitary Service for India and ask leave to submit them to the Congress for consideration.

The conditions which justify us in putting forward these proposals may be briefly summarized thus :—

1. The prevailing high mortality due to preventable diseases such as tuberculosis, malaria, sepsis, puerperal and other osteo malacia, intestinal complaints and the various epidemic diseases.

2. The natural ignorance and superstitious practices of the people who have had little or none of the counteracting influence of education in hygiene.

3. The fact that we in our daily work see how the evil centres in the home and can only be coped with there at its origin. The woman controls the home and she herself must be made the agent for remedial action.

We are fully aware that coercive measures are impossible and it would be futile to propose them.

We suggest a scheme for disseminating ideas of sanitation organised on such lines as will ensure that the new agencies are welcomed and even invited into the home.

Preliminary.—Before further advance can be made in sanitation, domestic or public—

(1) it is essential that a post-graduate course leading to a diploma in Public Health be instituted in every University centre;

(2) it is also necessary that midwives and indigenous *dhais* be registered, everywhere, both in villages and towns;

(3) we further suggest that model villages be constructed and managed on sanitary principles in various parts of each province, to serve as object-lessons.

The Scope of the Service.—We suggest that the duties of the officers would come mainly under the following heads :—

1. To assist in the registration of births and deaths and in the notification of diseases.

2. To report major insanitary conditions, and to show how minor defects may be improved.

3. To teach hygiene by public demonstrations and lectures and in schools and in homes.

4. To supervise midwives and *dhais*.

Organisation and Recruitment.—It is essential that all the officers be well educated tactful women of the highest moral character and specially suited to teach in schools and homes—

1. The whole provincial service for purposes of administration and inspection should be under a chief officer belonging to the Sanitary Department who should be a medical woman with a D. P. H.

2. Every district should be under a District Sanitary Officer who should also be a medical woman with a D. P. H.

3. There should be a subordinate staff of Indian and Anglo-Indian women, specially trained and living in their homes, in the villages and towns.

If Indians, these women should be not less than 25 years of age if living with their husbands; and not less than 40 if not living with husbands.

1. *Training.*—As already said, the Provincial head officer and District officers should be fully qualified medical women with the D. P. H.

2. The members of the subordinate staff should possess certificates of having had not less than three years' training in sick-nursing and midwifery in good hospitals.

In addition they should be put through a course of practical sanitation under the District Sanitary Officer for a period of six months. This course should be very simple and based on house-to-house visitation for the purpose of training the commonsense of the pupils, to note defects and apply remedies, as well as of instructing the people. Periodical visits should also be paid to the model villages for purposes of demonstration. For the futherance of her work the District Officer should be well supplied with models illustrative of the various branches of her work; also lantern slides, vernacular leaflets, diagrams and pictures.

Above all a cinematograph apparatus should be included in her camp outfit, with vernacular letterpress, illustrating and explaining as far as possible all subjects connected with hygiene and the care of children. Both in town and village this would be an immense attraction and we may point out that one side of the sheet may be enjoyed by the general public, while the other is reserved for purdah.

We suggest the nurse's training as a preliminary to the special training of the subordinate staff because it secures the following advantages:—

1. The nurses have had a training in practical cleanliness, and have lived in hygienic surroundings; also hygiene has been taught as a subject in their course of training.

2. By the practice of their profession they would gain entrance to homes and the confidence of the people.

3. The pay required will be less because they can take fees for attending patients.

Pay.—We advise that the District Sanitary Officer should not be allowed private practice and therefore should have adequate remuneration.

The pay of the subordinate staff should be graduated according to work done as reported on given forms and inspected by the District Officer.

Further suggestions.—Each village or group of villages might be encouraged to send up a suitable woman for training, who would return to live and work among her own home surroundings. All scholarships should be subject to the condition that the recipient should thus return.

Another method through which sanitation work could be developed would be through the chief women of the families of the headmen of the villages. These women might be persuaded to receive instruction from the District Sanitary Officer, who would use all possible means to impress on them hygienic principles in the home, including those involved in midwifery and in the care of children.

NURSE DISTRICT VISITORS IN MADRAS CITY.

BY

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President, Corporation of Madras.

In May 1913 owing to the prevalence of malaria in an acute form in the northern portion of the City a grant of Rs. 1 lakh was made by the Madras Government to the Corporation to be spent in malaria preventive measures. Among other measures, it was decided to employ six nurses on house-to-house work on a maximum salary of Rs. 200. In May 1913 applications were called for, but although the number of applications was very large, I was only able to select three women, two lady doctors, and one nurse, who appeared to me to be really suitable for the work. Later on I was able to make three more appointments and the staff of six nurses was completed on 1st July 1913. I mention this because I think it very important that the greatest care should be taken in the selection of nurses for this work.

The northern portions of the City were divided into six areas and a nurse was put in charge of each. Her instructions were to go round the district in the morning and evening, to make herself known to the people and advise them either to send fever cases to Hospital or to let her treat them. She was on no account to attempt to use compulsion of any kind, and if the people did not wish to take her advice she was to leave them alone. With the exception of one lady doctor, who was already known in the district where she had to work, all the nurses had very much the same experience. The people were at first suspicious and averse to allowing themselves to be treated. After a very short time, however, they began to bring their children for treatment, later the women came to be treated themselves and finally the men either allowed themselves to be treated or consented to go to one of the malaria dispensaries.

The following Table I gives the results of Splenic index surveys. I, of course, make no direct deduction from these figures as to the actual results of the nurses' work, because preventive measures by mosquito brigades were being carried out at the same time. What I can say from personal knowledge is that the nurses, besides treating a large number of cases themselves, were very largely responsible for the number of persons who attended the malaria dispensaries. They had the effect of gaining the confidence of the people in the measures which are being taken.

TABLE I.

No.	Different places or Pettahs.	Highest Splenic Index recorded in the places.	First Survey.		Second Survey.		Remarks.
			Date of survey.	Splenic Index.	Date of survey.	Splenic Index.	
		%		%		%	
1	Dhobipet ..	100	Feb. 1913	88·5	July 1913	58·6	Third survey in August 1913. Splenic Index 55·1%.
2	Tondiarpet (Paracherry)	70	April „	31·3	Aug. „	14·13	
3	Kassimode ..	64	Do.	28·3	July „	10·4	
4	Sanjivarayanpet ..	48	May „	5·5	Oct. „	1·3	
5	Kosapet ..	43	Do.	3·8	Sep. „	3·3	
6	Korukupet ..	66	Feb. and March „	36·3	July „	26·9	
	Kannialpet ..	..	Feb. „	31·7	July „	16·3	

TABLE II

SHOWS THE ACTUAL NUMBER OF VISITS TO PATIENTS.

MONTHS.	MRS. J. A. WALKE.		MRS. BULLOCK.		MRS. CHAMIER.		MRS. BURMAN.		MRS. JOHNSON.		MRS. SPEARS. MRS. SHAW.	
	No. of Consultations.	Quinine used.	No. of Consultations.	Quinine used.	No. of Consultations.	Quinine used.	No. of Consultations.	Quinine used.	No. of Consultations.	Quinine used.	No. of Consultations.	Quinine used.
		lb. oz.		lb. oz.		lb. oz.		lb. oz.		lb. oz.		lb. oz.
May ..	1,487	1 11	59	0 1	485	0 9	..	..	..	..	652	1 3
June ..	3,049	3 1	1,044	1 6	685	0 13	..	..	604	0 12	248	0 5
July ..	1,036	1 5	1,108	1 2	880	1 1	643	0 13	780	1 3	309	0 6
August ..	482	0 8	923	0 14	735	1 1	706	1 7	676	0 7	763	0 14
September .	401	0 7	401	0 7	418	0 11	554	0 12	337	0 5	559	0 10
	6,455	7 0	3,535	3 14	3,203	4 3	1,903	3 0	2,397	2 11	2,531	3 6

Total consultations 20,024 (consultation = visit per patient) ; Quinine distributed 34 lb. 2 oz.
The total consultations given by nurses do not give an idea of the actual number of cases or individuals treated.

TABLE III

IS DIVIDED INTO TWO PERIODS—THE FIRST, MAY, JUNE AND JULY ; AND THE SECOND, AUGUST AND SEPTEMBER.

MONTH.	Mrs. Walke appointed on 6th May 1913.				Mrs. Chamier appointed on 8th May 1913.				Mrs. Bullock appointed on 18th May, 1913.				Mrs. Johnson appointed on 28th May 1913.				Mrs. Burman appointed on 1st July 1913.				Mrs. Spears appointed on 5th July 1913.*				REMARKS.
	Acute.	Chronic.	Splenic.	Total.	Acute.	Chronic.	Splenic.	Total.	Acute.	Chronic.	Splenic.	Total.	Acute.	Chronic.	Splenic.	Total.	Acute.	Chronic.	Splenic.	Total.	Acute.	Chronic	Splenic.	Total.	
May ..	..	..	..	..	..	..	..	39	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
June ..	..	..	..	..	..	..	..	325	..	..	..	304	..	..	..	24[illegible]	..	..	..	..	..	..	..	..	
July ..	..	..	..	..	..	..	..	360	..	..	..	2	..	..	..	292	..	..	..	643	..	..	..	309	
Total ..	..	..	..	..	..	..	..	1,07	..	..	..	306	..	..	..	537	..	..	..	643	..	..	..	30	
August ..	..	30	66	96	17	25	28	70	2	..	..	2	26	25	11	62	15	..	17	32	9	9	3	21	
September		81	49	130	14	27	3	44	7	..	..	7	5	33	1	39	16	..	4	20	12	6	..	18	
Total ..	..	111	115	226	31	52	31	114	9	..	..	9	31	58	12	101	31	..	21	52	21	15	3	39	
GRAND TOTAL ..	..	..	..	226	..	..	..	1,189	..	..	..	315	..	..	..	638	..	..	..	695	..	..	..	348	

No. of Malaria cases treated by all the nurses and lady doctors from the beginning of their operations up to the end of September. } 3,411.

* Mrs. Spears acted for Miss Shaw who was appointed on 7th May 1913.

Though these nurses were appointed primarily for malaria work, they are doing very useful work in other directions. They instruct mothers in home and personal hygiene and in the care and feeding of infants. One nurse who is working among fairly well-to-do people tells me that undoubtedly one of the main causes of the high infantile death-rate is the ignorance of the mothers. There is nothing new in this, but I mention it because I am convinced that no better agency could be employed for the removal of such ignorance than carefully selected district visiting nurses.

Again in removing ignorance as to the real causation of Malaria invaluable work may be done. In the area just north of the City the popular belief was that malaria was caused by the tanneries in the neighbourhood because of their offensive odour. In the northern part of the City, the area now being dealt with, the people believed that the malaria was caused by the sewage farm because the farm occasionally emits a smell. In both areas it was widely believed that quinine causes a diseased spleen. In such erroneous ideas again there is nothing new and again I only mention them because the nurses working in the north of Madras have been able very largely to dispel these ideas by getting right home to the people, instilling

knowledge as to prevention of malaria and giving practical demonstrations of the effects of quinine.

Another direction in which the nurses have done very useful work is that of cleanliness in and around the houses and in the streets. They are continually instructing the people in habits of cleanliness and their instruction has had an effect. They have also brought about an improvement in the work of the Municipal subordinates. When a woman of the right type makes up her mind to have a place cleaned up she generally gets her way and these women have had an electrifying effect on the subordinates in the Conservancy Department.

In another direction nurses doing house-to-house work may be of the very greatest service, I mean in the tracing out of diseases in the home of the people. In the discovery of cases of pulmonary phthisis the Health Officer tells me that the work of these nurses may prove of considerable value.

When I read this paper through it strikes me as being mainly superfluous; it seems to amount to a statement that the nurses employed in Madras are doing just the work which one would expect nurses to do. But there is one point of vital importance on which our experience may be useful. From the experience of these nurses at the beginning I am convinced that if the right stamp of nurse were not available it would be infinitely wiser to employ none at all. Inexperience, want of tact, impatience at the start might easily have the effect of alienating the people and thus doing more harm than good. The women employed must be physically strong, not young, with considerable experience and of course with a really thorough knowledge of the vernacular. To employ younger or less efficient nurses on lower pay would in my opinion be a fatal error. I would prefer to employ women with medical qualifications if available, and I would pay them well.

INFANT MORTALITY.

BY

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As this question is one which requires serious consideration at the hands of every hygienist, I venture to bring it before the notice of the Conference with a view to arriving at certain definite conclusions. Let us first go into the general question and endeavour to show the immense waste of human lives due to infant mortality by referring to the statistics :—

During the year 1912 in the Punjab the Infantile Mortality rate was 210·44 for males and 210·13 for females. At Amritsar alone the mortality amongst infants is very high as shown in the following table :—

Year.	Total births.	Deaths of children of six months and under.	Deaths of children of six to twelve months.	Still births.
1910	7,300	1,025	1,306	574
1911	7,051	1,096	530	548
1912	11,712	1,197	1,558	518

Under the term " still births " I include every child born dead or died within an hour or two of its birth.

If we take the healthiest year 1911 out of the three, the above statistics show :—

(1) That one out of every thirteen children was still-born.

(2) That before entering the second year of their lives 2,174 died out of 7,051, in other words, approximately one out of three died within the first year of its life, leaving two out of three to enter the second year. This was the state of affairs when the town was free from every kind of epidemic. If the infants had such a high death-rate when the town was comparatively healthy the conditions during an epidemic will be something terrible.

I. The fact that one out of a dozen children was still-born shows :—

(*a*) The want of sufficient knowledge on the part of women about pregnancy.
(*b*) Early marriage.
(*c*) Diseases of women such as gonorrhœa, syphilis, etc.
(*d*) Abortion.
(*e*) Overwork during pregnancy.

II. That the highest number of deaths occur during the first year of the life of an infant can be safely ascribed to :—

(*a*) Entire disregard on the part of the mother about the science of child-rearing and infant hygiene.
(*b*) Ignorance about the life they should lead during pregnancy.
(*c*) Unconscious bringing up of children on the poorest quality of sophisticated and skimmed milk as sold in the streets.
(*d*) Quack midwives being easily procurable are commonly favoured.
(*e*) Diseases like small-pox and malaria.
(*f*) Overcrowding.

Infantile mortality ranks high as an evidence of the health of a community. Hence in reducing infantile mortality to a minimum we not only put a stop to the preventable loss of human lives but improve the health of the community as well. With this view in mind we must elucidate some of the causes given under heads I and II above.

Early Marriage.

Early marriage is a social evil in India which no law can eradicate unless the people offer their helping hand. The inception of new ideas by mixing with races which are socially advanced is sure to make its good effects felt by raising the marriageable age in India, thus helping indirectly to reduce the infantile mortality, but this is a slow form of progress. Although the Punjab is ahead of other provinces in this respect, yet the number of early marriages is still large and the custom requires considerable reformation and opens a field big enough to absorb the activities of hundreds of National leaders. The cure rests with the people ; it is they who can mould their own destinies by giving education to their females on broader lines than heretofore done, and the Government is sure to back them up in the realization of their hopes ; old customs will die out, premature consummation of marriage will become a thing of the past and the health of the community as a whole will be greatly improved.

2. Infant Hygiene, Pregnancy and Maternity.

Entire ignorance of the life a woman should lead during pregnancy and maternity, and complete disregard of the science of infant hygiene amongst the majority of Indian mothers, are factors which go a long way to contribute to high infant mortality. Every Sanitary Officer who has had something to do with visiting the streets and lanes in Indian cities will bear me out when I say that Indian mothers have been observed feeding themselves, and their infants at breast, on everything "going," often with the result that the infant's life comes to a premature end. All this can be remedied if only men in India do a little of their duty towards their own wives and daughters and impart to them the necessary education in elementary hygiene.

Nature is a cruel master, as you sow so shall you reap is her immutable law. Sanitary laws are promulgated with the object of so regulating the lives of the people that Nature's products, air, food and water, may be supplied to each and all in such a manner and under such conditions that the vital forces of every individual may be maintained at their maximum. I wonder how many of the Indian families keep that view before their mind's eye. The reply would be unfavourable in the case of a vast majority. The inevitable result must follow in the shape of lowered vitality, increased susceptibility and consequently high mortality amongst children. Our duty as guardians of the public health is to put a stop to this high mortality by devising means which may suit the conditions obtaining in India. It is well known that the Punchayat system is still prevalent and dates its origin from times immemorial. That such a system does exist shows that the custom of forming societies in India, discussing social and religious questions in them, and abiding by their dictum is innate amongst Indians. Taking advantage of this sterling quality amongst the masses in India, I would propose the formation of Provincial Health Societies with branches in the different towns in India for the definite object of inculcating the knowledge of Nature's laws and the fundamental principles of domestic economy and hygiene.

The times have changed and so has India, new lines of research have been opened up, new sciences have been born, old truths are seen in quite a new light, venerable dogmas are accounted as old wives' tales or flippantly disregarded as out-of-date. Amid all this innovation the public are bewildered, legislators perplexed, and I for one do not wish to add further to their bewilderment by recommending the constitution of separate societies for "prevention of cruelty to children," "the protection of women and children," a society each for "Anti-malarial," "Anti-tuberculosis" and "Quinine Prophylactic" purposes, and so forth ; the society I have proposed will include all the minor sanitary subjects and I am sure the knowledge acquired by the Indian public through the agency of such an institution will give forth sparks enough to kindle the flames of a cleansing and purifying fire which will burn brightly and steadily through the length and breadth of the Indian Peninsula.

The above is a measure which is to be adopted mainly by the public themselves. The next question is, what steps should be taken by local bodies and the State towards achieving the object in view.

India is the only country I think where women play a major part in the household economy and unless they come to the front no good will ever result out of all our exertions for the betterment of an Indian home in point of sanitation. It is to them that we must look for help. Women lead very gregarious lives in India. Therefore if one woman is influenced successfully, rest assured that through her you have spread your influence through a wide community of door-step acquaintances. For them there is no "close season" for babies, and to them the babies are a subject of inexhaustible interest. We must educate them in the ways of looking after themselves and their children, particularly their infants. Much of this can be done by hardworking, tactful and sympathetic lady health visitors. It is through such

an agency only that we can obtain our object and it is here that the local bodies and the Government should come to the rescue of the people.

Physiologically speaking a baby is a frightfully hard worked individual; during the first four months of its life it increases to double its weight at the time of birth, meaning thereby that a baby has to provide a credit account largely to the good because it has not only to grow but make up the loss as well. There are a thousand and one agencies at work against the unfortunate baby, and it is uphill work getting the better of them, but one sure ally of the baby is the baby itself. It is against the natural order of things that babies should die, and that gives them a wonderful tenacity. Nature has only one object in view and that is race maintenance which can be very well illustrated by taking the case of an animal like the dog or cat. Wherever there are great risks attending the developments of the young of any animal, the young are produced in such numbers as to leave a large surplus for fatalities, while on the other hand where the young are produced in comparatively small numbers they receive a corresponding protection and prolonged maternal care. All this proves that, barring accidents, if a baby dies, it dies, strictly speaking, through sheer neglect of its parents, especially its mother, and any steps taken to civilize her hygienically mean restoration of life to infants and curtailment of their excessive mortality.

Biologically speaking, a baby is an entity long before it is born. From the time it is a unicellular organism with all the potentialities of a full size human being, an individual existence is going on which grows steadily by cell divisions and all the complicated processes of folding in and pushing out and splitting into layers, formation of cavities, and so forth, until in due course from a shapeless mass of cells a miniature edition of a grown-up person enters the world. During this time it is absolutely dependent on its mother for its nutrition and as in the case of other mammals the human mother has to do everything for its offspring. She has to supply it with food and oxygen and keep it warm, clear its waste products and over and above all she has to prepare a future dairy for it. Thus we see clearly that if we want to safeguard the baby and give it a good start in life it is the baby's mother who should know how to look after herself wisely during the first nine months of the baby's life in utero, for the baby is alive all that time, although living in strict retirement.

After what has been said above it should be clearly understood that the mother's well-being, as also the well-being of the developing baby, are inseparable and their physiological interests are identical. It is of absolute importance for a mother to know all about the child in utero, the best ways to bring it up after birth and the life she herself should lead after parturition.

To gain the ears of such mothers it is necessary again to appoint Lady Health visitors who should go amongst them as their friends, educating them on simple sanitary questions and teaching them how to live healthy and keep their children fit. At the same time there is a large opening for trained voluntary workers as well, who would act under the Public Health Department. There is indeed a large scope for women who want an outlet for philanthropic energies to carry out the work, each being given only a few houses on which to concentrate their attention.

The duties of such voluntary and paid visitors will of course be to wage a war against ignorance and quackery, superstition and prejudice, and to preach the doctrine of preservation of infant life in every household. Sympathy with our fellow beings is the key to success, and the time has come when we can do something towards the diminution of these appalling death rates by introducing into our work against the dry materialism of this world a little more of the elevating influence of human sympathy.

3. Quack Midwives.

The question of midwives in India also requires thorough scrutiny. Old grand-mothers, quack midwives, and untrained nurses pose themselves as duly qualified obstetricians and are considered as such by the general public in India on account of their sheer ignorance. Such women have been the cause of a fairly good proportion of deaths amongst infants. Their notions of asepsis, if any at all, are of the crudest type possible—delivering one child here and another there without properly cleaning their hands, cutting the umbilical cord of newly born babies with an ordinary pair of septic scissors or a knife rusty and black with stains; tying it with a dirty piece of thread or an old rag, dusting the navel with ash are a few instances enough to make one's hair stand on end. To deal effectively with such malpractices I am strongly of opinion that Government should step in and introduce an act like that of Midwives Act, 1902, of England and Wales, with slight modifications to suit the country.

4. Overcrowding.

Another cause which tends to increase infantile mortality is overcrowding and our crusade will be a failure if we leave it unattacked. Sanitation concerning houses has no significance at all for an Indian landlord. There is no ideal standard of cubic space, ventilation, angle of light, etc., for them to follow. Houses are made in a haphazard fashion without even an elementary knowledge of hygiene. Overcrowding due to joint family system and poverty is common. Want of light, poor internal ventilation, and want of free circulation of air without, are structural defects which the present day landlord does not think worth his while to pay attention to, and the result is that every facility is afforded for disease to gain a footing. The pernicious system of back to back houses in dark and dingy lanes, the most objectionable practice amongst the landlords to make their houses in filthy streets with sheds for cattle under the residential rooms, are facts which require serious consideration at the hands of the public, local bodies and the Government. There is much to be done in India in the matter of housing.

Pallor, anæmia, anorexia, tuberculosis, tonsillitis, scrofula, etc., are some of the troubles which women living in congested areas suffer from.

In this connection I would propose that the Government be asked to press local bodies to use their powers more freely under the provisions made by different Provincial Municipal Acts. The Municipalities should be forced to make certain rules and resolutions to which every new building should conform. The Health Officer should be freely consulted in matters concerning house sanitation and he should be provided with facilities for frequent inspection of city houses.

Concerning house inspection steps should only be taken after mature consideration, as any imprudent movement in this direction might be resented by the people and amount to a desecration of the sanctity of the zenana.

5. Milk.

As artificial feeding has become a necessity now, milk as sold in bazars is highly inimical to the health of an expectant mother or a developing child, and is responsible to a much larger extent for the deaths of infants due to gastro-intestinal ailments. It is an established fact now that milk in India is as impure as it can be, and it is time for the sanitarians, the public, local bodies and the Government to take early steps in this direction for the protection of infants, who will eventually be the workers of the State.

As far as the Punjab is concerned, the present legislation is fairly adequate to meet the ends in view if the local bodies take them up in a right earnest way. It is no use asking for fresh legislation until we are satisfied with the incompetency of the present Acts. I would only suggest that to distinguish between good and bad milk and eliminate the adulterated samples there *should be some legal standards fixed.*

It should be the duty of every Municipality to supply at ordinary bazar or even lower rates good unadulterated milk to every poor woman who has an infant to bring up. This can be done by establishing a Municipal Dairy on a small scale to start with. Such a dairy could be run according to the most hygienic principles possible, and will not only be a source of supplying the mother of the child with good pure milk, but will serve as a model dairy as well, to be copied by other dairy owners in the town and elsewhere. This will awaken the interest of the public towards the most important question of pure milk supply and its effect on infantile mortality.

Every big Municipality should be furnished with a small Laboratory for the analytical and bacteriological examination of milk.

I have tried to indicate the goal to be attained and the means by which it might be reached, as briefly as I could, and trust that this Conference will discuss the various points raised in my paper with that skill and assiduity which has characterised its work in the past, and without which the community it serves would have been the poorer in that greatest of all earthly blessings, health.

HIGH TEMPERATURE AS A CAUSE OF INFANTILE MORTALITY.

BY

MAJOR W. H. KENRICK, I.M.S.

IF infantile mortality, above a certain level, is dependent upon the temperature of the air, we should expect to find in places subject to high temperatures,—

(1) an increase in the number of deaths during the hottest month of the year;
(2) an increase during years of exceptional heat.

The record and charts of infantile mortality in the Central Provinces and Berar, which follow, will show that this is the case.

In 1912 exceptionally high temperatures prevailed in parts of India, during a part of the months of May and June.

On the 8th May in the Central Provinces west, and Central India west, the daily temperature began to rise above normal.

From the 12th onwards, the North-West of India, the United Provinces (except the north-east), the Central Provinces east, and Central India, all began to experience abnormal heat.

Gujarat reached the maximum on the 14th when 121·8° was registered at Deesa. The maximum was reached in the Central Provinces west, Sind, and Rajputana on the 15th with 116·7° at Akola, 126° at Jacobabad, and 120° at Jodhpur. In the Punjab, the Central Provinces east, and the United Provinces west, the maximum was recorded on the 16th with 120·4° at Montgomery, 119° at Chanda, and 117·5° at Jhansi. These unusually high temperatures began to fall on the 17th May, and normal conditions were reached by the 19th and 20th. Again from the 3rd to the 9th June high temperatures prevailed, though not to the same extent as during the previous month.

The following Chart No. 1 giving the deaths of infants, the deaths of children from 1 to 5 years of age, the total deaths, and the births, month by month during the year 1912, for the Central Provinces and Berar, shows the rise in infantile mortality during the heat of May.

This curve shows that the rise of 12,297 in the total number of deaths (from 37,841 in April to 50,138 in May), was largely formed by an increase of 9,878 in the number of infants' deaths, the deaths of children (1 to 5 years of age) increasing by 2,127 only. The excess infantile deaths during the excess heat of May and June represents an addition of 21 per mille births to the annual infantile death-rate.

This rise in the infantile mortality in May accompanies a rise in the maximum shade temperature, and the fall in June corresponds to the lower June temperature; in July the maximum temperature was down to 98·6°, and the infantile mortality lower than in any month, except February.

During the latter part of the year the whole province suffered from a widespread epidemic of cholera, and infant life was again affected, though not to the same extent as that of young children.

During the first-half of June the maximum temperature, though lower than in May, was very high, the average in Nagpur being 110·7°, while for the latter half of the month it was only 104·3°, this would account for the partial fall in the June mortality curve. To obtain the average temperature of the province, I have taken the mean maximum of all the 12 recording stations for these months (April, May, June, July), the records of which are at hand.

If the mortality curves of all the Central Provinces and Berar districts for 1912 are charted, this rise in the number of infant deaths, as shown in the Provincial chart, during the heat of May, is found to be contributed to by each district, those districts, as Betul, Mandla, etc., which enjoy a cooler climate in May, than the districts of the plains, being only slightly affected.

The following table includes all those districts which maintain meteorological stations:—

CHART No. 1.

CENTRAL PROVINCES AND BERAR.

1912.

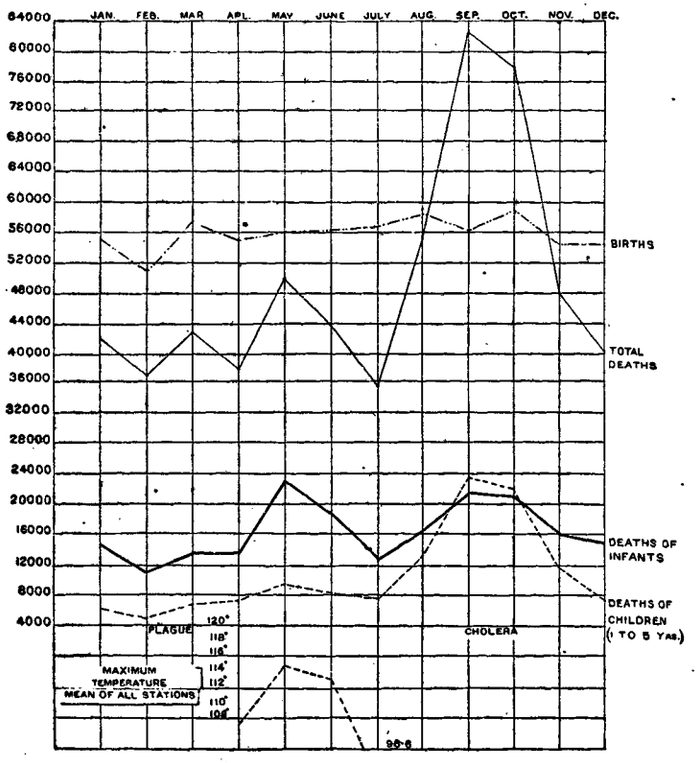
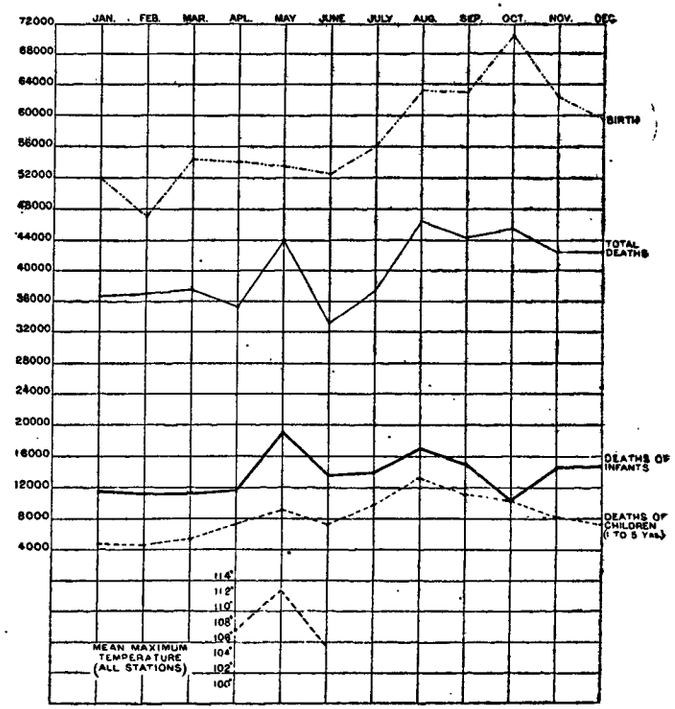


CHART No. 2.

CENTRAL PROVINCES AND BERAR.

1911.



These two Charts, while useful for contrasting the effects of the higher temperatures of the plains' districts with those of the lower temperatures of the plateau districts, are not intended to demonstrate the results of a difference of a degree or two in the maximum temperature of one plains station from another, *e.g.*, Chanda and Raipur; they only show the maximum temperature recorded upon one day during the month; the high temperatures being more prolonged in some districts than in others, would naturally influence the rise in infantile mortality.

Infantile deaths, 1912.

Districts.	Maximum shade temperature, May.	Departure from normal.	Feb.	May.	Percentage increase.	Remarks.
Betul	104%	?	385	415	7·7	
Mandla	105% average.	(Gazetteer)	219	292	33	1912 temperature not known.
Chhindwara ..	111%	?	405	591	46	
Jubbulpur ..	113·3%	7·8	476	707	48	
Saugor	113·3%	8·1	445	712	60	
Seoni	112·1	8·4	295	504	70	
Raipur	116·7	9·4	1,074	1,875	74	
Chanda ..	119·5	9·5	459	1,016	121	
Nagpur ..	117·1%	7·5	826	1,897	129	
Buldana ..	109·2	?	541	1,318	143	Temperature not representative.
Akola	116·7	8·9	584	1,510	158	Some cholera present.
Amraoti ..	115·8	7·9	607	1,598	163	
Nimar	116·2	9·6	320	881	175	Cholera slight.
Hoshangabad ..	116·1	8·4	431	1,237	187	Cholera very bad.

With regard to the temperature records in the above table, although recorded at one station only in each district, with the following exceptions, they represent fairly accurately the heat prevailing throughout the whole district. The Buldana observatory is 2,156 ft. above the sea, while nearly two-thirds of the population occupy the low-lying Payanghat, which has an elevation of only 865ft. and experiences the intense dry heat associated with the Berar plains, 114° therefore would more closely represent the Buldana heat. The Chhindwara station is representative of all but the Sausar Tehsil (29 per cent. of the population), while the Seoni temperatures would slightly understate the prevailing heat.

Betul has the coolest climate of any district in the Central Provinces, Mandla has much the same elevation as Betul, and enjoys a cool and pleasant climate. The May temperatures throughout would be slightly higher than those of Betul as the villages are more shut in by surrounding hills.

Although Chhindwara and Seoni are plateau districts, nearly the whole of the southern tehsil of the former, and small areas on the south and north-west of the latter, are situated in the plains, and therefore subject to higher temperatures than the Betul and Mandla districts. Seoni generally records a higher temperature than Chhindwara, as the following figures show :—

	1910.		1911.		1912.		Remarks.
	May.	June.	May.	June.	May.	June.	
Chhindwara	103·7	102·2	106	111·1	103·9	91·1	Mean maximum temperatures.
Seoni	104·6	98·8	108·2	96	105·7	92·4	

This fact, combined with some small-pox, might account for the position of Seoni, on the list with reference to Chhindwara, Jubbulpur and Saugor.

In Hoshangabad district cholera was widely prevalent during May, the epidemic spreading also to Nimar, and this undoubtedly added to the great increase in infantile mortality in these two districts.

There was practically no plague in the Central Provinces and Berar during this month (42 deaths only), and small-pox existed to a very slight extent in Seoni (34 deaths), Nagpur (134), Chanda (21), Raipur (43), Amraoti (39), and Buldana (50). Cholera, as mentioned, was severe in the Hoshangabad district only. Epidemic disease, therefore, can have taken little or no part in producing this great increase in the infantile death-rate.

Mortality curves for the year 1911, which also recorded unusually high temperatures during May, together with a table showing the temperatures and mortality for the districts separately, are shown below :—

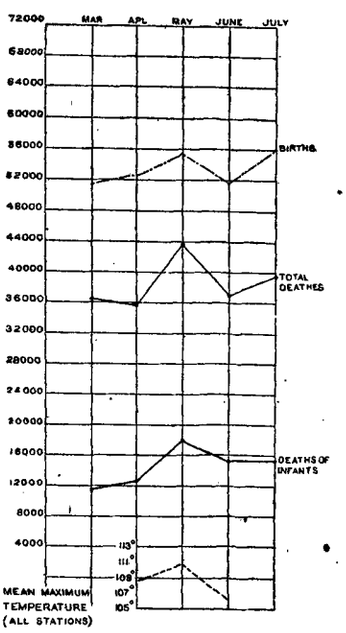
District.	Maximum temperature, May, 1911.	Departure from normal.	Infantile deaths.		Percentage increase.
			Feby.	May.	
Betul	101°	?	385	328	..
Chhindwara ..	109·5°	?	407	478	17
Mandla	?	?	207	248	19
Seoni	110·1°	6·2	274	381	39
Chanda ..	114·5°	5	608	904	48
Amroati ..	112·8°	5·4	587	1,875	49
Akola	115·2°	7·5	648	990	53
Saugor	116·6°	6·3	453	759	67
Buldana ..	108·1°	?	542	920	69
Nagpur ..	114·6°	5·2	717	1,212	69
Hoshangabad ..	113·6°	6	332	592	79
Raipur	113·7	6·2	1,078	2,028	88
Jubbulpur ..	114·2°	7·7	241	512	112
Nimar	114·2°	7·7	241	512	112

The temperature of Buldana is not representative, and Chanda had an unusually high death-rate in February as during the month of March there were only 459 deaths, there was also a high death-rate in February in Amraoti, Akola, Buldana, and Nagpur, 111° would more nearly represent the prevailing heat in Buldana.

CHART No. 3.

CENTRAL PROVINCES AND BERAR.

1910.



In the year 1910, although as much as 113·5° to 114·5° of heat were reported from several stations in the province, the mean maximum temperature for the 12 recording districts was only 110·8°, the following chart (No. 3) gives the infantile and total mortality for the months, March to July.

The charts, as in the case of the provincial chart for 1912 (No. 1), show :—

(1) that the sharp rise in the total number of deaths in May is caused almost entirely by a rise in the infantile mortality;
(2) that this latter has no connection with the number of births during the preceding months;
(3) that children aged 1 to 5 years were only affected to a very slight extent;
(4) that the increased mortality corresponds closely with an abnormal rise in the maximum temperature;
(5) that practically no increase in the number of deaths occurs in the Betul district, which escaped the abnormal heat;
(6) that cholera, while increasing the number of deaths of infants, affects children (1 to 5 years) to a much greater extent.

In this connection it is interesting to note that if curves of the total monthly mortality as well as of the mortality at age periods, under one year, and from one to five years (which of all age periods appear to be the most reliably reported) are charted, it is possible from the curves alone to distinguish epidemics of cholera, plague, small-pox, also hyper-endemic malaria, as well as influences solely affecting infant life, *e.g.*, in cholera the rise in total mortality is contributed to by children in much greater proportion than by infants; in plague neither infants nor young children are affected to any great extent; in small-pox the rise in infants and children's mortality is in much the same proportion, *viz.*, 20 to 25 per cent. infants, and 25 to 30 per cent. children from 1 to 5 years of age, the adult mortality (all ages above 10 years) being 60 per cent.; with hyper-endemic malaria, the rise in the death curves is mostly shared by infants and children's deaths in equal proportion. The period of the year is also indicative.

If infantile mortality is raised by excessive heat, one would expect to find some correspondence between the daily temperature when above a certain degree, and the daily number of deaths; the following charts show this relationship well.

In the case of the Amraoti chart, five registration circles were chosen at random, by reading the names off the map, as they came, no selection at all being made, the daily number of deaths as reported by the village Kotwals being obtained from the police registration officers. The circles are those of Daryapur, Asagaon, Chandur Bazaar, Loni-barur, and Nandgaon. I have not included the Sirkhed Circle, as the records for 1911 are missing, but in this circle, out of the 80 infantile deaths in May

1912, 46 occurred during the four days, 15th to the 18th May, *i.e.*, during the period of excessive heat. The climatic and economic condition of all these circles is practically similar, and they all alike shared in the rise in mortality. The curve for May 1911 shows three moderate rises corresponding to three periods during which the maximum temperature was a few degrees above the normal, and 223 infantile deaths were registered during the month against 348 in May 1912.

The large fall to below normal in the maximum temperature of the first-half of June 1911 is associated with an infantile mortality of only 65, in contrast to June 1912, when the persistence of abnormally high temperatures is marked by the death of 103 infants during the same period.

During the month of May 1912 there were only 25 deaths from cholera throughout the whole district of Amraoti, against 296 deaths in June, the deaths from small-pox were reduced from 62 in April to 39 in May, there was no plague and deaths from respiratory diseases were also on a diminishing scale, all these causes can therefore be eliminated.

There was a slight increase in the number of deaths from dysentery and diarrhœa, *viz.*, 126, but as the infantile mortality increased by 847, this cause may also be set aside.

During May 1911, on the other hand, there was some plague, cholera, dysentery and diarrhœa prevailed to an equal extent, while small-pox and respiratory diseases were slightly less than in 1912. The marked difference in the two years is in the record of deaths due to fevers. During the first four months of the year there were only 108 more deaths, under this heading, in 1912, than in 1911, whereas in May the excess was 508, that is to say, in the non-malarious cotton tract of Amraoti the fever deaths rose from 917 in April to 1,484 in May.

As there was practically no increase in the deaths of other than infants, *viz.*, 1,804 in April and 1,809 in May, while infantile deaths increased by 847, we are justified in assuming that the majority of these deaths were included under the heading "fevers."

It will be noticed that although abnormal temperatures prevailed during June 1912, the thermometer was over 113° for one day only, against the four days of May, and this, combined with the fact that many of the weakly infants would not have survived the May heat, probably accounts for the excess mortality being less in June than in May.

Charts 4, 5, and 6 give the mortality curves of separate districts, *viz.*, Nagpur, Amraoti, and Betul, the first represents the conditions, as shown by their own charts, of every one of the plains districts of the Central Provinces. Amraoti represents all the Berar districts, while the Betul chart is a record of the more elevated plateau districts.

In other respects the meteorological features of the two periods, in May and June 1912, were much the same, *viz.*, 30 degrees difference between the maximum and minimum temperatures, 20 degrees between the wet and dry bulb thermometers, and the wind W. N.-W., the only real difference besides the maximum temperatures was in the movement of the wind, which in May was about 410 and in June only 194 miles per 24 hours.

The Nagpur City (Chart No. IX) shows in a still more marked degree the effect of heat on the death-rate. The deaths were daily reported at the municipal office and a complete record maintained.

During May there was no cholera, plague deaths numbered five only, and small-pox eight, while in May 1911 there was neither plague nor cholera, but small-pox accounted for 11 deaths.

Thus the increased mortality cannot be ascribed to any of the above named.

Malaria is non-existent in Nagpur during May, yet 173 deaths are put down to fevers in May 1912, compared with 86 for the previous May.

From the Nagpur charts it will be seen that on May 15th, 1912, the maximum temperature suddenly rose from 110·5° to 116° and remained at and above this high level for 5 days. Coincident with this rise the infantile deaths increased from 17 for the week ending May 14th to 137 for the week of excessive heat, or seven times the average mortality of the remainder of the month, the deaths fell again to 45 during the following week of sub-normal temperatures.

From the 3rd to the 10th of June fairly high maximum temperatures associated with an abnormal infantile mortality again prevailed.

As there must naturally be considerable variation in the power of resistance of different infants, one would expect an increased mortality for some few days after the fall in the temperature, as was the case during the period May 22nd to June 1st.

In May 1911, although abnormal temperatures prevailed, they were combined with considerably lower minimum temperatures, *e.g.*, 83° and 84° compared with 90° and 92° in Nagpur, May 1912.

All the other cities in the plains, the daily figures of which I have been able to see, show a greatly increased mortality during the seven days period of the 1912 heat wave.

CHART No. 4.
NAGPUR DISTRICT.
1912.

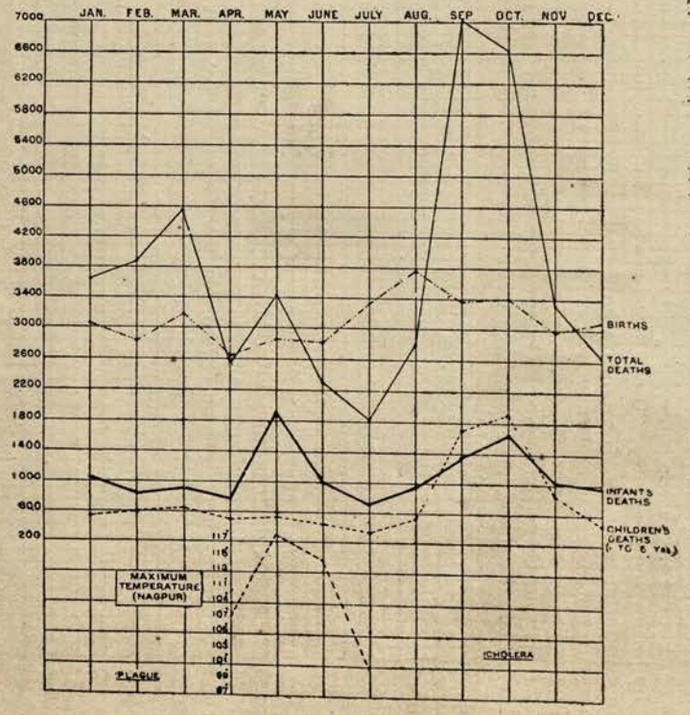


CHART No. 5.
AMRAOTI DISTRICT.
1912.

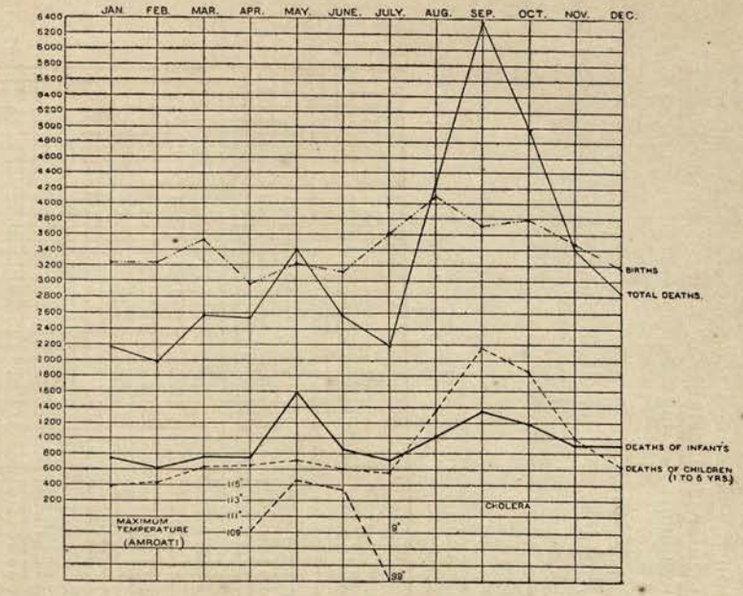

JAN. FEB. MAR. APR. MAY. JUNE. JULY. AUG. SEP. OCT. NOV. DEC.
BIRTHS
TOTAL DEATHS.
DEATHS OF INFANTS
DEATHS OF CHILDREN (1 TO 5 YRS.)
MAXIMUM TEMPERATURE (AMROATI)
CHOLERA

CHART No. 6.
BETUL DISTRICT.
1912.

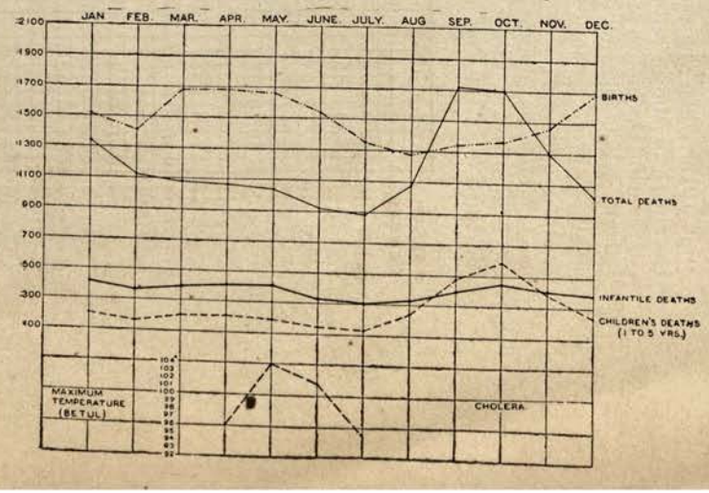


CHART No. 7.

AMRAOTI DISTRICT.

1912.

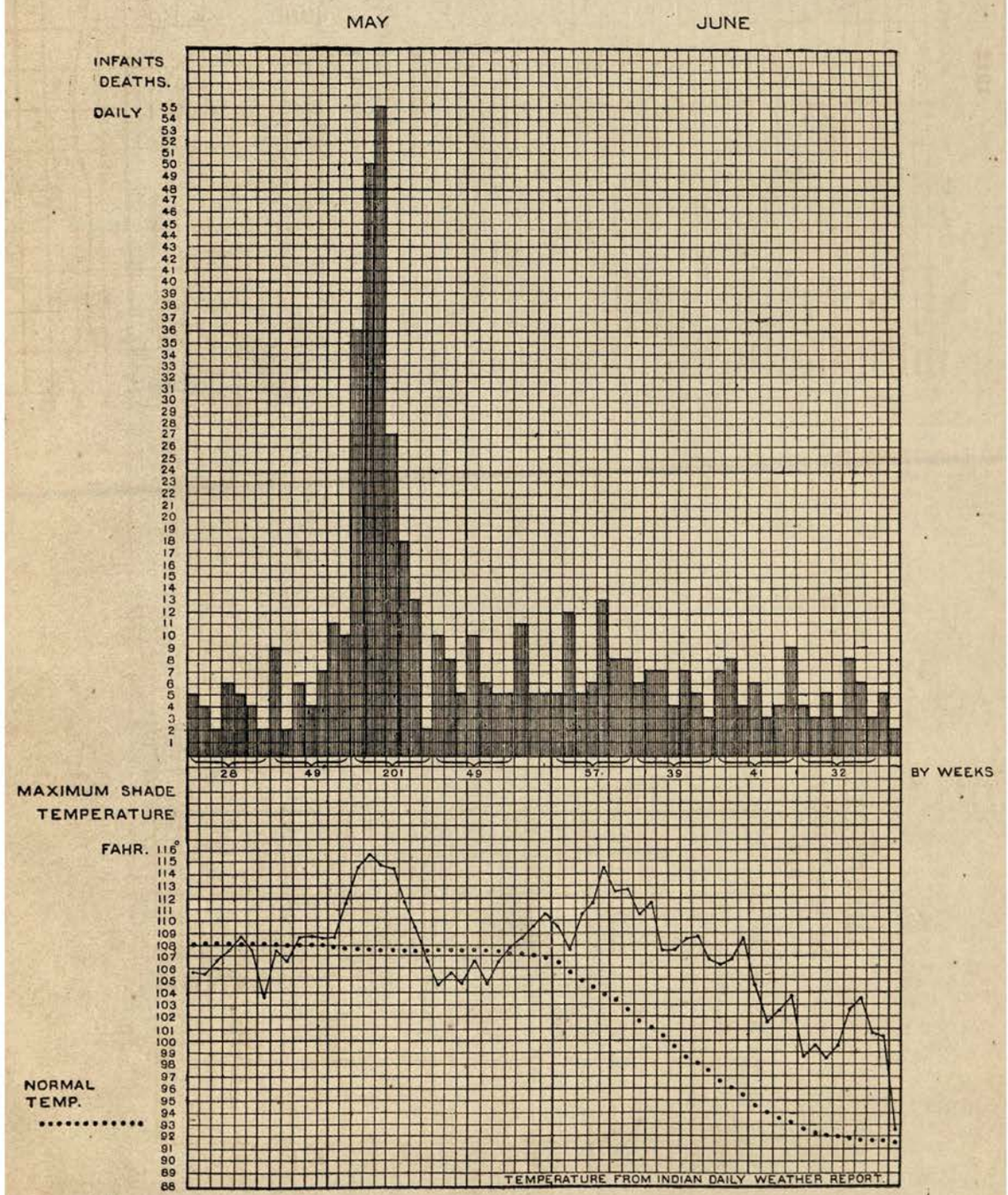


CHART No. 8.

AMRAOTI DISTRICT.

1911.

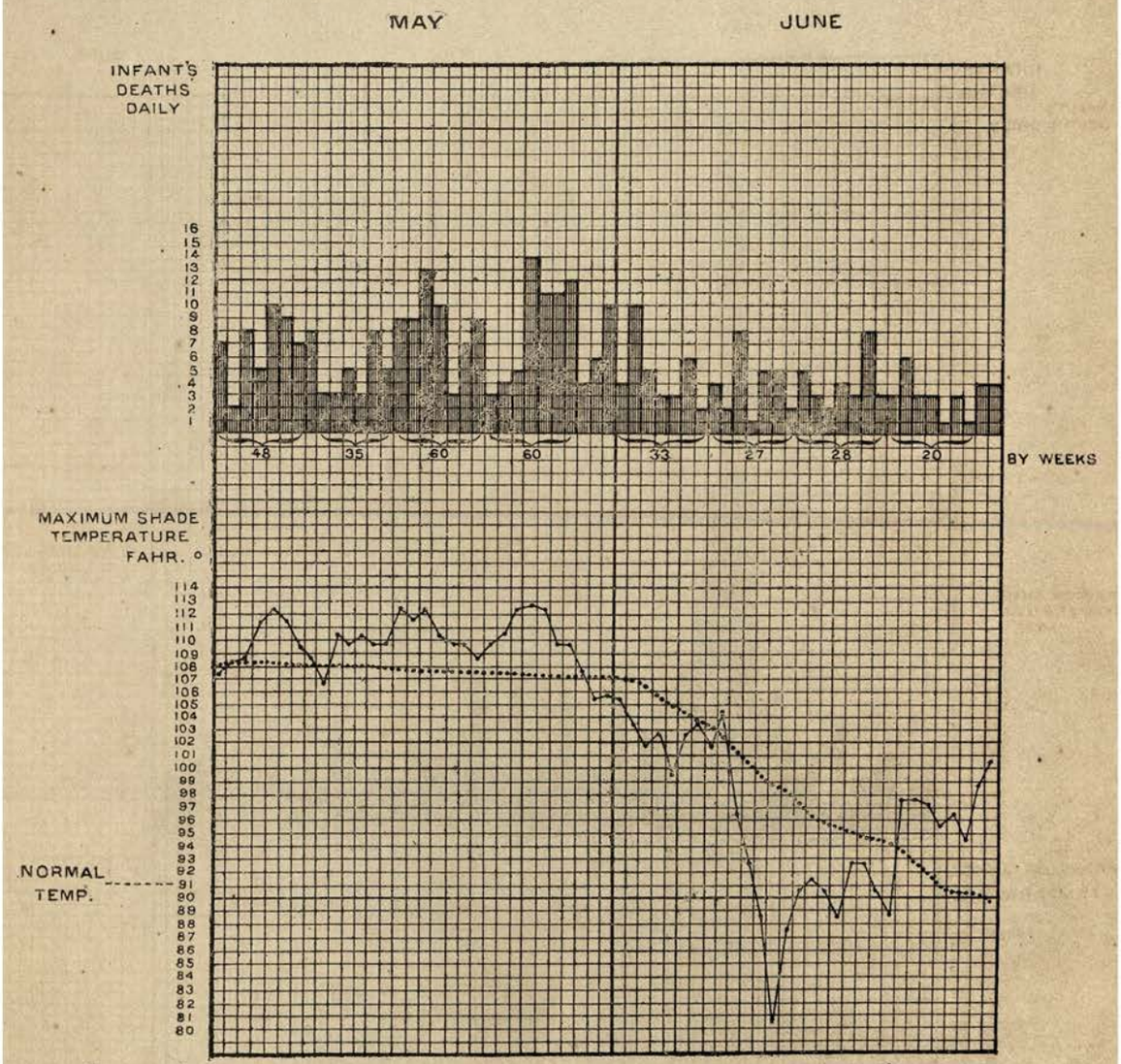


CHART No. 9.

NAGPUR CITY.

1912.

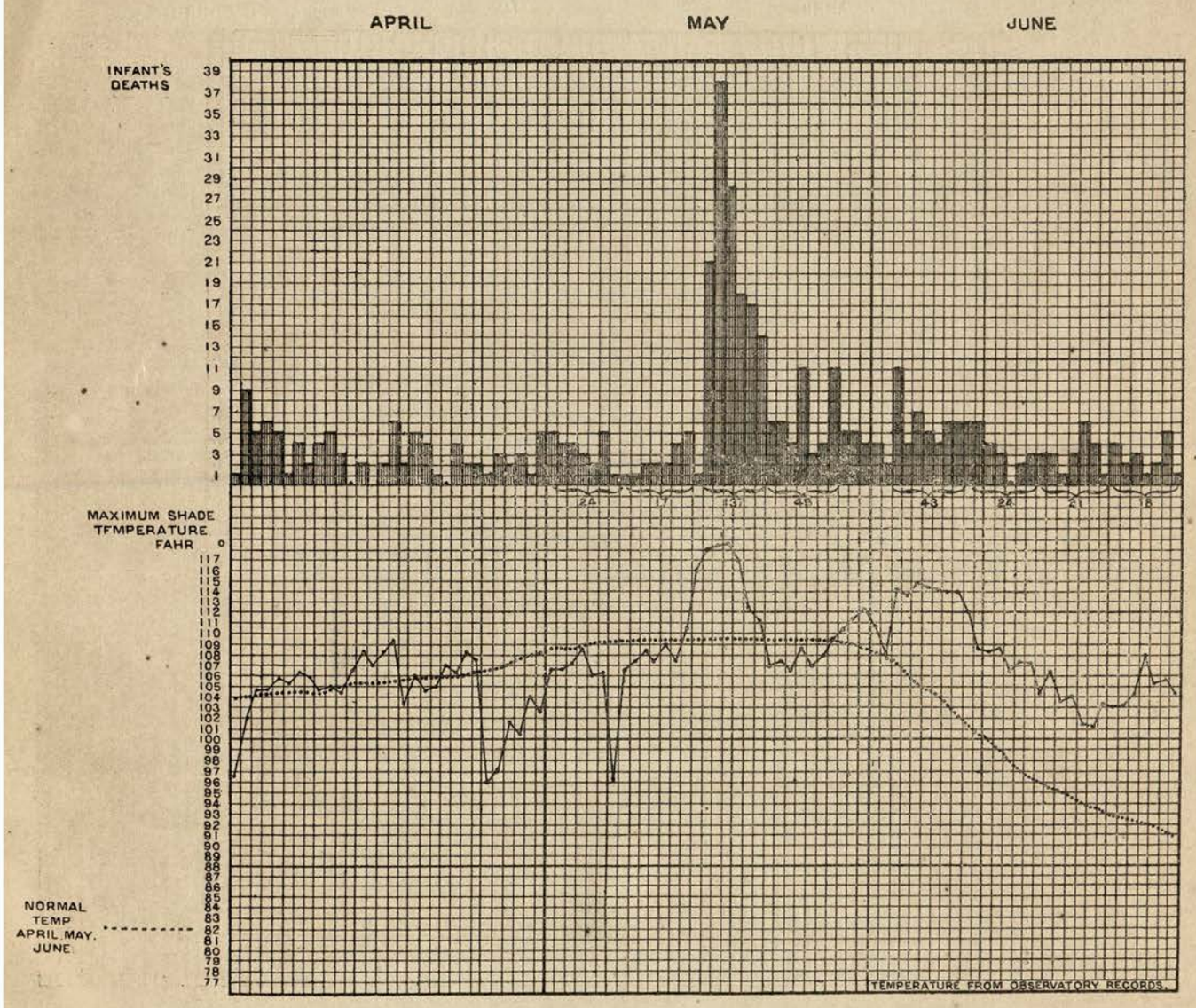
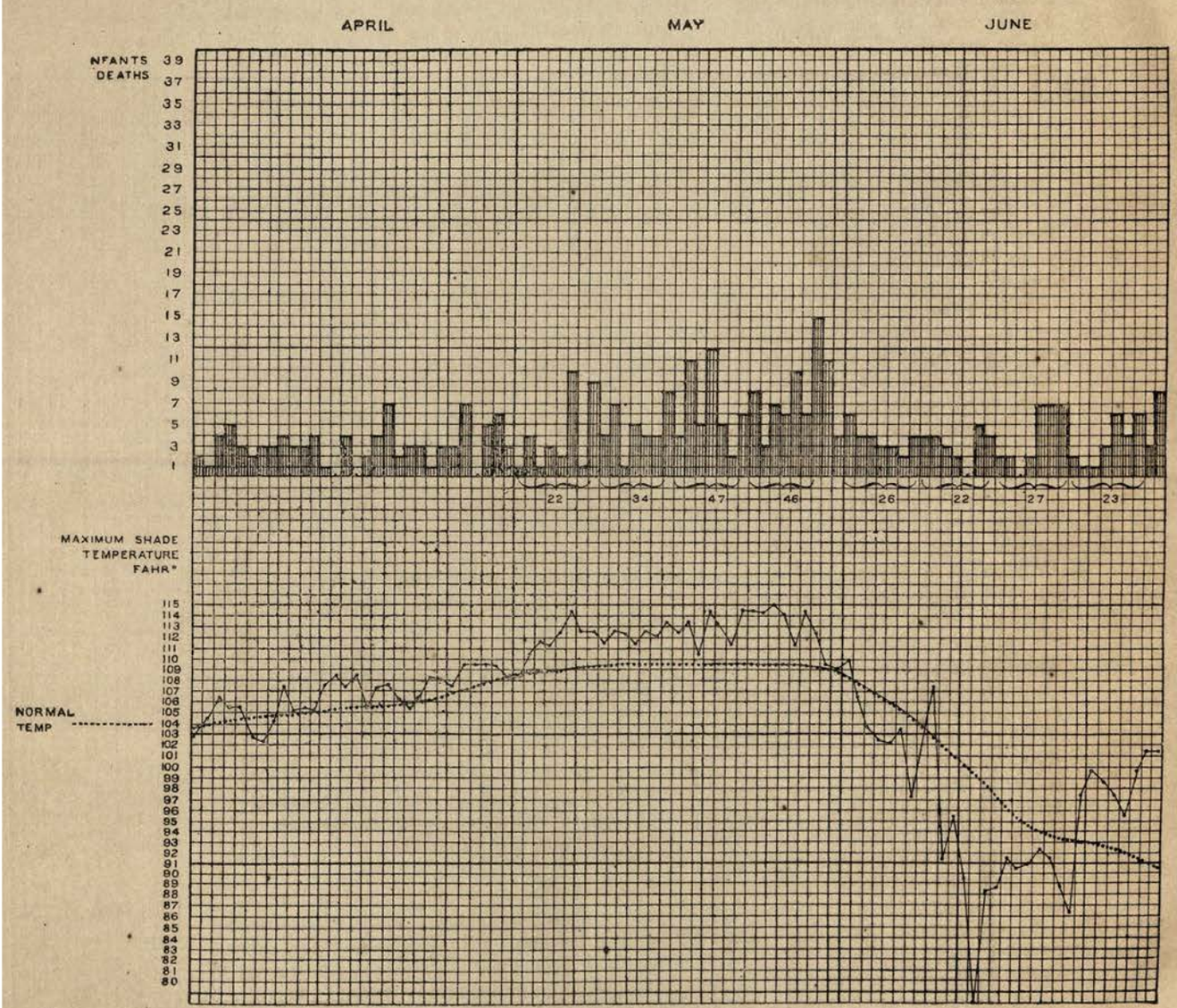


CHART No. 10.

NAGPUR.

1911.



In Chanda City the mortality was 4·6 times the average of the remaining portion of the month, in Burhanpur four times, in Amraoti City it was three times, and in Yeotmal and Khandwa it was double; while the daily record of the Khandwa Thana rural circle shows three times the average mortality.

The chart of the Betul district (No. VI), with its comparatively low May temperatures shows no marked rise during the month.

I have been able to obtain the daily figures of the Budnur (Betul) station house circle, which includes a number of villages, and although the figures are small they help to explain the district curves. Out of 23 deaths in May, only four occurred from the 15th to the 21st of the month.

The reasons for excluding small-pox and measles as the cause of the increased infantile mortality during May in the Central Provinces and Berar, are the following:—

In the case of small-pox, many children and adults would have died, the mortality for infants being only 25 per cent. of the whole small-pox mortality, while that for persons above the age of 10 years is 60 per cent. (*see* "Small-pox and Vaccination" by Major S. P. James, and "Annual Report of the Sanitary Commissioner with the Government of India"), whereas the increase in the general death-rate for May 1912 was made up as follows:—

Infants' deaths, 80 per cent.
Children's deaths (1 to 5), 17 per cent.
Other age periods, 3 per cent.

Further, April is a slightly more fatal month for small-pox than May.

In 1912 there was comparatively little small-pox in the Central Provinces and Berar, *viz.*, 4,550 deaths, April being the worst month with 744 deaths. In other years there has been a considerably heavier small-pox mortality with a lower infantile death-rate, *e.g.*, in 1906 there were more than double the number of deaths, while the infantile death-rate was 14 per mille less than in 1912.

As regards measles, it is difficult to imagine an epidemic so widespread as to involve, besides other parts of India, nearly the whole of the province, and yet leave untouched a district as Betul, which has a large and constant interchange of traffic with Berar and Nagpur.

Moreover, as the charts of daily mortality in Nagpur, Amraoti, etc., show, the large increase in infantile mortality was confined to a short and definite period, *viz.*, May 15th to May 20th, and was at its height throughout the province, as the daily death records of such widely separated places as Nagpur, Amraoti, Khandwa, show, on a certain date, *i.e.*, May 17th (the maximum temperature of the year having been recorded on the previous day at nearly every station in the Central Provinces and Berar). This is not the case with measles which spreads from point to point, and is not usually and rapidly fatal, and which, if in destructive epidemic form, attacks old and young alike.

Further, measles when fatal is generally so from lung complications during a widespread epidemic, therefore, one would expect a great increase in the number of deaths from respiratory diseases; during May 1912, however, the total respiratory deaths for the whole province increased by 225 only.

Though not much reliance can be placed upon the diagnosis, it is noteworthy that the deaths from measles and chicken-pox dropped from 5,502 in 1911, to 3,589 in 1912. Betul district which had a very slight rise in the infantile death-rate for May, reporting the third largest number of such deaths; while many districts in which there was a marked increase in the number of infants' deaths, reported a reduction in the measles mortality.

Malaria need hardly be taken into consideration. May is one of the least malarious months of the year, when water is scarce and anophelines, especially in the open cultivated areas of the plains, difficult, if not impossible, to find. The marked preponderance of infants in the death returns, the involvement of non-malarious areas as Berar, the absence both of malarial symptoms, and resultant splenic enlargement, are all strongly against this disease as a cause.

There is another disease in connection with infantile mortality which should be considered, that is infantile diarrhœa; that this disease, however, plays no part in the present case, is evident from the following facts:—

(1) the total number of deaths from dysentery and diarrhœa was no greater in May than in July, when infantile mortality was near its lowest point;
(2) infantile diarrhœa is a disease of the third quarter of the year;
(3) recent evidence goes to show that the extent of this disease is directly proportional to the number of flies prevalent, but it is a well-known fact that flies diminish greatly in number as the temperature of the hot weather rises, and during extreme heat very few can be found; it is unlikely, therefore, that the mortality of May 1912 can be ascribed to fly-borne disease.

In endeavouring to account for the high infantile mortality in the Central Provinces and Berar in May and June 1912, we can definitely exclude cholera, plague, diarrhœa, malaria, small-pox and measles, also other infectious and parasitic diseases, as apart from other reasons the simultaneous involvement of nearly the whole province contra-indicates such.

The area of country involved, and the characteristics of the mortality curve, point clearly to some meteorological phenomenon as the cause, and we are justified in concluding that the abnormally high temperatures which prevailed during the period of excess infantile mortality were the cause of the latter.

Other provinces.—On account of the rains and easterly winds during the greater part of May, a large part of Bengal, Assam, and the eastern part of the United Provinces did not experience the high mean temperatures recorded in the Central Provinces and elsewhere.

Over a large part of the Punjab the mean temperature does not rise as high as is the case in the south-west part of the province (Multan and Montgomery), and in the central parts of India.

In Madras, the North-West Frontier and in parts of Bombay and Burma the mean temperature is always lower.

I am able to give the statistics of certain of the districts of other provinces which also experienced the intense dry heat of May.

In the United Provinces, Jhansi City reported an infantile death-rate of 321·4 per mille of births, and in the district 716 infants died during May against 488 during the month of April. In Agra district 911 infants died during May 1912, which was 22 per cent. in excess of the average May mortality of the last 4 years. The high temperature during June also was responsible for a greatly increased infantile mortality in these two districts.

In Hamirpur the annual death-rate was 278 per mille of births, and Farrukhabad, Etawah, Fatehpur and Jalaun all record high infantile mortality, while the eastern districts which enjoyed a lower mean temperature returned comparatively low rates.

In the Punjab, Montgomery district reported in May 1912, 345 infants' deaths, against a four-yearly average of 292; this figure is the highest recorded during the period March to June, of the years 1909 to 1912.

In the Multan district also the 535 deaths in May are greatly in excess of the average of the other hot weather months.

At Ahmedabad in Gujarat, the infantile death-rate in 1912 was 795 per mille of births, and during May 902 deaths under five years of age occurred; which, if we take only half of this number to be infants, means that considerably more infants died than were born during the month.

The actual cause of death.—From enquiries which I have conducted among parents who have lost their children, private practitioners and others, it appears that pyrexia, and exhaustion combined, are the main cause of death. I am told that the body temperature often rises to 106° F., respiration and pulse are greatly accelerated, the infant is unable to obtain nourishment, becomes at first fretful, then drowsy, and dies of exhaustion.

I found that many of the infants had previously been weak and ailing, although this was not always the case, occasionally healthy ones succumbing.

As the death-rate in the larger cities, as Nagpur, Burhanpur, etc., was higher than that in the smaller cities, it is natural to suppose that conditions, as density of population, site-crowding and the nature of the houses, whether designed to protect from the heat or not, must all exercise some influence upon the mortality rate.

The presence of coincident epidemics as cholera also accentuates the destructive effects of heat on infantile life, as seen by the return of the Hoshangabad district.

The question remains what can be done to lessen the appalling waste of infant life during a period of excessive heat? We must rely upon a gradual improvement of the insanitary conditions under which a large part of the population at present lives, the opening out of congested areas, and an improvement in the construction of houses.

Much might also be done in the larger towns, at the onset of a period of abnormal heat, to warn and advise people against the risks of unnecessary exposure of infants to the heat.

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Shri Brihad Bhartiya Samaj

on 31 October, 2019